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# HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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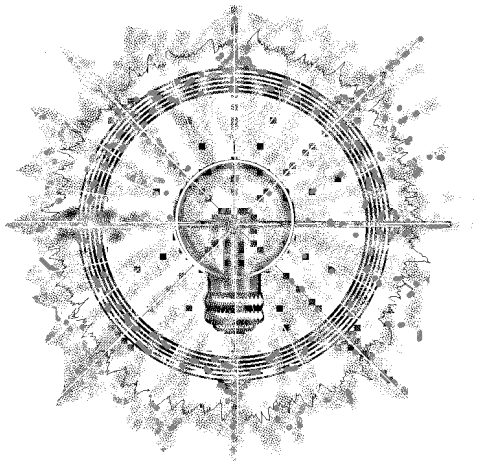

# HOME POWER

## THE HANDS-ON JOURNAL OF HOME-MADE POWER

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### Think About It

"A vision with a task is but a dream.
A task without a dream is drudgery.
A vision with a task can change the world."

Black Elk
(from HP reader Carolyn Mercer-McFadden)

### Cover

STI students raise photovoltaics in downtown Carbondale, Colorado.
Story on page 6.

Photo by Chrissy Leonard.

From us to YOU

# The Cutting Edge

I salute Home Power Readers for their ingenuity, determination, and hard work. Articles about realistic renewable energy use pour into Home Power from everywhere. Consider the work in this issue by Dick Linn, Harmut Ginnow-Merkert, Al Rutan, L.E. Spicer, and Hollister McNeal. These articles represent years of unsubsidized, unofficial, and superproductive renewable energy research.

The cutting edge of renewable energy is using the hardware we already have, not making 32% efficient, tandem-junction PVs that no one can afford. The cutting edge is using solar cookers. The cutting edge is using efficient appliances. The cutting edge is application.

We already have the technology and hardware. Look at what the authors in this issue alone are doing. These are folks who are using renewable energy on their own. They use it without government support, without tax credits, and without engineering degrees. These folks are light years ahead of the hopelessly high-tech scientific establishment.

People who see the sun shine on the cutting edge want to talk about it. There is something very infectious about cooking dinner in a solar oven or lighting the house with sunshine at night. Folks who have invited renewables into their lives are happy to share experiences. This is what you will find within these pages.

Home Power provides access to information. This is not information about the future–you will find no pie-in-the-sky dreams here. This is the experience of those who are actually living on renewable energy. This information is as real as sunrise.

We are here to tell you renewable energy is not the wave of the future. Renewable energy is today, and for many of us, thousands of yesterdays.

We invite you to enjoy and to share. After all, the supply is unlimited and free for the taking.

*Richard for the HP Crew*


## People

Sam Coleman
Charlie Cowden
Gerhard Dekker
David W. Doty
Kathleen Jarschke-Schultze
Harmut Ginnow-Merkert
Bernie Haines
Kirk Herander
Mike Kilgore
Stan Krute
Sam Landes
Chrissy Leonard
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Hollister McNeal
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Therese Peffer
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Bob–O Schultze
Alan Sindelar
L.E. Spicer
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Steve Willey

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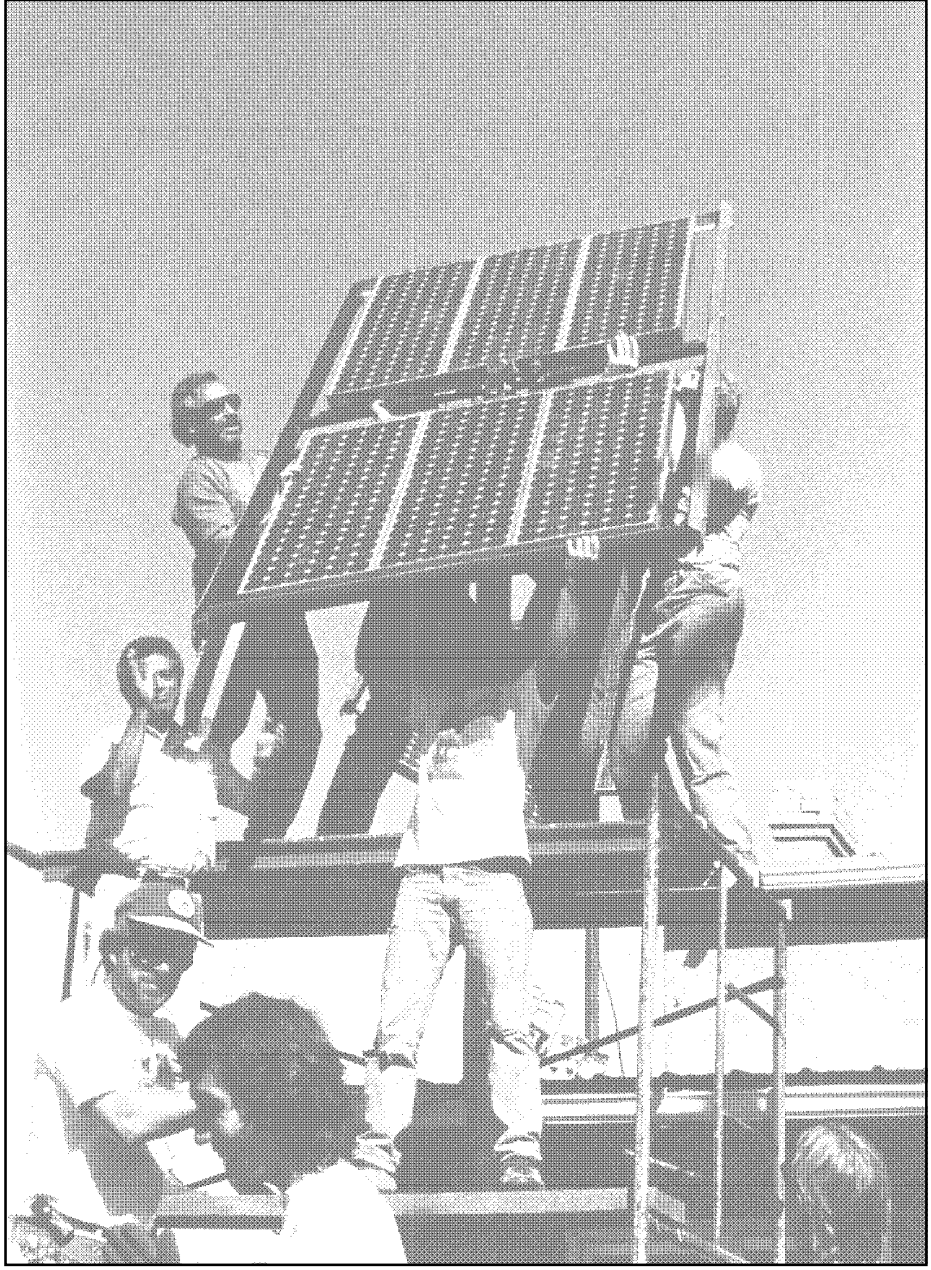


Above: STI students put the PVs, mounted on their Zomeworks tracker, atop a steel pole. Many hands make light work. Photo by Chrissy Leonard.

# Solar Power Is Happening Here

Richard Perez

Main Street in Carbondale, Colorado isn't much different from any other in America, except for the PV-powered home of the Solar Technology Institute (STI). STI uses solar energy to electrify their educational extravaganza, right under the nose of the local coal-burning utility.

**Location**

Carbondale, Colorado is located on the west slope of the Rocky Mountains not far from Aspen. At six thousand feet altitude, STI's home gets its share of snow and low temperatures. The Solar Technology Institute is centrally located downtown, right in the middle of Carbondale's business district. It is impossible to drive by without seeing the pole-mounted photovoltaic (PV) arrays.

**People**

Solar Technology Institute is a very impressive sounding name. Names are a matter of imagination. What really counts are the people behind the name. In the case of STI, the people are Ken Olson and Johnny Weiss. Ken and Johnny have been teaching hands-on solar technologies for the last ten years. They are active in the Cold Chain Project bringing PV-powered vaccine refrigeration to developing nations. After installing hundreds of PV systems for others, Ken and Johnny will finally have solar power for themselves.

**Purpose**

I participated in STI's two week intensive course in photovoltaics for remote homes. The participants came from Columbia, Dominican Republic, Mexico, Alaska, Hawaii, California, Vermont–from all over. The first week of the course consisted of seminar sessions in the mornings followed by lab and workshop sessions in the afternoons. The subjects covered in the first week included: basic electricity, instrumentation, batteries, controls, inverters, wiring, efficient appliances, NEC requirements and more. The second week of the course

consisted of installing PV systems at STI's downtown site.

It was the second week that had me worried. I'd done many seminars and labs, but I had never before installed systems with a group of twenty-five people. I wondered about the complexities of the wiring. As it turned out, the STI students installed everything with no problems.

**Loads**

Usually a photovoltaic power system's design starts with estimating the energy consumption of the loads. Well, STI's situation was backwards. The loads powered by the system were determined by how much power the system could produce. Solar Technology Institute is a non-profit educational organization. Almost all the equipment we used was donated by manufacturers and distributors. These farseeing people realized the advantages of having STI students using their hardware. Fortunately, the STI stockpile contained first rate hardware.

Ken and Johnny had a long list of equipment including copiers, computers, overhead projectors, lighting, and electronics to power from the system. To further complicate things, the leased building uses a large furnace fan for winter heating. We decided early on to leave the heating system on the grid and concentrate on powering the office and educational loads with PVs.

**The System's Design**

Actually we designed and installed three distinct PV arrays. One large (six modules on a Zomeworks tracker) and two small, each with two modules. All these modules power STI via the main battery and inverter.

Part of the course was a presentation and discussion with


Above: The Advanced PV for Remote Homes Class at Solar Technology Institute, on September 27, 1991. Never have I worked with a more dedicated, down-home, or delirious crew. Photo by Chrissy Leonard.

John Wiles (author of Code Corner in HP) of the Southwest Technology Development Institute. The topic was National Electric Code (NEC) approved PV systems. The entire class decided that the STI system would contain all the code required equipment and would be wired according to NEC specs. All wiring would be in conduit. All power sources would have NEC-approved fused disconnects. In short, a Skookum system right down to the color coding on the wires–black for positive, white for negative, and green for ground.

**Energy Sources**

The source of the power is sunshine directly converted into electricity by photovoltaic modules. The main system at STI uses ten PV modules made by Spire. Each 45 Watt module has an output of about 3 Amperes at 15 Volts DC. The ten modules were wired in parallel to make an array producing 30 Amperes at 15 VDC. On an average day, these arrays will produce 2,900 Watt-hours. Eight of the modules are mounted on two Zomeworks Track Racks (one holds six and the other two modules) that follow the sun's path. The remaining two modules are mounted on a Zomeworks stationary pole mount.

Each module was parallel interconnected with 10 gauge wire with sunlight resistance USE insulation. All current handling connections on the arrays were soldered. Each module had its own 10 gauge grounding wire attached to the module's framework with a self-tapping sheet metal screw. The large tracker's framework and the five inch diameter steel pipe supporting the tracker were grounded using 6 gauge bare copper wire. A waterproof enclosure was mounted on the tracker's pole. This enclosure housed the connections between the individual wires from each module and the larger #2 aluminum cables carrying the power to the system. The mechanical connections made inside this enclosure were made with 250 MCM Al/Cu lugs and with antioxidizing grease.

The PVs rise above the roof of STI's home like a solar phoenix. The constantly moving trackers attract the attention of all who see them. The message is clear–solar power is happening here.

**Energy Storage**

Storage is primarily in alkaline nickel-cadmium batteries. The STI system used thirty Edison ED-160 nicad cells to make a battery of 480 Ampere-hours at 12 VDC nominal. This battery was generously donated to STI by John D'Angelo of Utility Free in Basalt, Colorado. These cells were reconditioned by Utility Free from previous railroad service. John was also kind enough to open his battery reconditioning shop to the entire class for a visit.

The batteries are housed outside the office in a wooden enclosure beautifully built by one of the STI students, Allan Sindelar. This enclosure not only contains STI's nicads, but also an assortment of lead-acid batteries. All the nicad cells are housed on stair-step racks that allow easy viewing of their electrolyte levels. A large four inch conduit pokes through the common wall shared by the battery compartment and the inside wall housing all the energy processing equipment. The inside of the battery enclosure is equipped with a four inch square steel raceway housing wires and cables.

Battery parallel interconnect cables and inverter cables were made by the STI students from 0 and 00 gauge copper welding cable. The students used the soldered copper tubing connector technique described in HP#7.

**Energy Processing**

A small room off the main office houses the energy processing equipment. Here an entire wall is covered with fused disconnects, controls, instruments, and inverters. Ropes of conduit connect everything together. There is not an exposed wire anywhere; everything is enclosed in either the raceway on the wall, in metallic conduit, or within an NEC-approved box. The result is an impressive array of electric stuff that rivals the bridge of either the Starship Enterprise or the Yellow Submarine.

The power flowing from the PV arrays first must pass through a two pole, single throw, 60 Amp DC-rated Square D disconnect equipped with 30 Amp DC-rated RK5 fuses made by Littlefuse. The input PV power then moves to the Heliotrope CC60C PV charge control. This switch also disconnects the battery from the charge control. If this disconnect is operated, then the charge control is disconnected from both the PV array and the battery, as per NEC specifications.

The Heliotrope CC60C PV control keeps system voltage under control. The CC60C uses Pulse Width Modulation (PWM) to maintain a user set voltage. This user set voltage limit can be set high enough (≈16.5 VDC in 12 Volt systems and 33 VDC in 24 Volt systems) to function well with alkaline batteries. The CC60C accepted the conduit fittings with no problems. This CC60C contains the factory installed LCD digital Ammeter/Voltmeter combo which is large in size and easy to read.

The inverter is the Trace 2012 with digital instrumentation and the new-model built-in programmable battery charger. This inverter supplies all the 120 vac loads connected to the system. This inverter allows the low voltage, direct current power made by PV modules to be consumed as standard 120 vac, 60 Hz. house power. And

Above: parallel wiring six Spire PV modules mounted on a Zomeworks tracker. The whole assembly is sitting face down on sawhorses. All connections made on the modules were soldered by STI students. Photo by Chrissy Leonard.

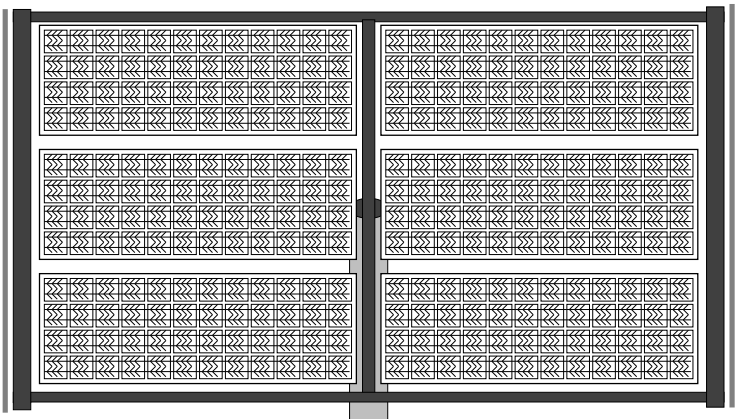
consuming it was on Ken and Johnny's minds. I took a look at the photocopy machines, overhead projectors, slide projectors, light tables, not to mention almost a kilowatt of fluorescents, and I knew that this Trace wasn't going to have an easy time of it. The output of the Trace inverter is fed into a second mains panel that supplies all of STI's wall outlets and lights.

This Trace is equipped with the new super sophisticated battery charger we reviewed in "Things that Work!" HP25, page 58. If STI has to use grid power to recharge their batteries, then at least there is an excellent charger around to do the job. There is a single grid connect outlet next to the inverter just for battery recharging. After much discussion the STI crew decided not to hook up the battery charger, but instead to live with the PV power made on site.

The Trace 2012 is connected to the battery by 00 gauge copper welding cable with hand-made, soldered copper tubing connectors. In series with the inverter/battery circuit is a Heinemann DC circuit breaker rated at 250 Amperes. This circuit breaker protects the inverter and its cables from over-current and also functions as a switch disconnecting the inverter from the battery. This highly specialized breaker is hard to find, expensive (≈$150), and required by the NEC. Many thanks to John Mottl of Rainshadow Solar for providing the one installed in STI's system.

The main instrument used to fly STI's system is a Cruising Equipment Ampere-hour meter. This instrument uses a shunt to sense and record all current flow both into and out of the battery. An ampere-hour meter serves the same function in a PV system that a gas gauge serves in a car. Additional instruments used in the STI system are the built-in digital Ammeter/Voltmeter in the Heliotrope

# Solar Technology Institute Photovoltaic System Diagram



*PHOTOVOLTAIC ARRAY*

Ten Spire 45 Watt PV Modules mounted on Zomeworks Trackers and Pole Mount (six modules on one tracker, two on a second tracker, and two modules on a pole mount). 450 Watts (30 Amperes at 15 Volts DC)

GND
PV–
PV+

FUSED DISCONNECT
Square D – DC Rated
30 Ampere RK5 Fuses

TRACE 2012 INVERTER
2 kW. at 120 vac, 60 Hz.

MAINS PANEL

Heinemann Circuit Breaker
250 Amperes

12.64
CC60C
PV PV Bat Bat
+ – – +

Heliotrope CC60C
PV Control

Shunt

BATTERY – 30 Edison ED-160 NICAD Cells
480 Ampere-Hours at 12 Volts DC

ED 160

-147
Amp-Hours

Cruising Equipment Battery Ampere-Hour Meter

2 Amp Fuse

GROUND ROD

charge controller, and the extensive instrument package built into the Trace inverter (battery voltage and battery charger functions).

**The Installation**

The installation began with a seminar on the system to be installed. We took a large greaseboard and drew the whole thing out. Every wire in the system was included in the diagram. I have attempted to reproduce this system diagram here.

Installation was complicated because the building was off the grid and powerless for two days. Separating the 120 vac circuits within the building took two commercial electricians two days to complete. During this grid-less period the STI crew set up three sets of batteries feeding four different inverters. This swamp of temporary systems provided the power to run all the construction tools. This temporary lashup gave everyone the opportunity to try a wide variety of power tools on four different inverters (Trace, Heart, Vanner, and PowerStar). Amazement was universal when the five pound PowerStar UPG1300 ran a worm drive Skil™ Saw.

Installing the trackers and the poles supporting the PV racks took two days. The main array (six modules on the big Zomeworks tracker) was placed on a fifteen foot length of five inch diameter steel pipe. This pipe was set into a five foot deep hole that was then filled with cement. The result was a secure mounting place for the Zomeworks Track Rack high in the air away from people and cars.

Several of the students took the task of fabricating the inverter/control/instrument panel. Here a sheet of plywood served as a back plane for mounting the various components. Another crew ran the conduit and wiring necessary to hook everything together. A third crew took charge of wiring the individual modules into arrays. Juan Livingstone of STI gets extra credit for swimming through the attic's insulation with conduit gripped between his teeth.

**System Performance**

It worked the first time the switch was thrown. The first evening that the system operated at STI was a fiesta. Sixty local solar supporters and the STI crew gathered for a barbecue and enchiladas cooked in a Sun Oven donated by its maker, Burns-Milwaukee. We had the lights and the stereo going until midnight. The Cruising Equip. Amp-hour meter said we used 148 Ampere-hours from the batteries in a six hour period. A highly electric time was had by all.

On a daily basis, STI lives within its energy budget of about 2.5 kiloWatt-hours daily. They have broken new ground by feeding business and audio/visual tools with inverters. Photocopiers have been known to fry and die when fed the modified sine wave power produced by inverters. At STI, Ken and Johnny have successfully used long list of business and education gear.

The Toshiba 2510 photocopying machine runs flawlessly on the Trace inverter. This copier is a high output, full-featured office model that sorts, enlarge, reduces, duplexes, and collates. Ken and Johnny said that the Toshiba engineers were very helpful and interested in the performance of their machine on inverter power.

Another full scale copier that functions perfectly on the Trace inverter was the Minolta EP5400. It has roughly the same features as the above Toshiba model and the test model even did color. The only copier Ken and Johnny tried that didn't work was the Ricoh 5540. The Ricoh 5540 didn't fry and die when powered by the inverter, but it made copies that were very poorly and inconsistently

*Solar Technology Institute's Electrical Loads*

| Load Description | DC Amps IN | DC Volts IN | DC Watts IN | Nameplate Watts |
|---|---|---|---|---|
| Copy Machine- Toshiba 2510 | 115.0 | 12.23 | 1406.5 | 1725 |
| Coffemaker– Mr. Coffee CMX-400 42 3 | 100.2 | 12.38 | 1240.5 | 1165 |
| Coffeemaker– Regal Drip type model 7564 | 75.3 | 12.57 | 946.5 | 900 |
| Microwave Oven– Sharp Model 40-60 | 67.3 | 12.72 | 856.1 | 400 |
| Overhead Projector– Apollo model AL1000 | 33.0 | 13.11 | 432.6 | 400 |
| Slide Projector– Kodak Carosel | 27.2 | 13.11 | 356.6 | 400 |
| Electric Hole Punch– Panasonic KX-30P1 | 16.9 | 13.35 | 225.6 | |
| Fluorescent– two 40 W. tubes w/coil ballast | 7.3 | 13.47 | 98.3 | |
| Computer– Zenith TurboSport LapTop | 5.4 | 13.66 | 73.8 | |
| Fluorescent Light- GE Compax FLG15L | 1.6 | 13.62 | 21.8 | 15 |
| Answering Machine– Panasonic KXT-1423 | 0.7 | 13.92 | 9.7 | |
| Surge Protector– unloaded | 0.7 | 13.61 | 9.5 | |

**all measurements are DC input to Trace 2012 Inverter powering the 120 vac load**

toned.

Standard audio/visual aids like the overhead projectors and slide projectors have little problem making the transition to inverter produced power. And since the business of STI is education, the system contains two coffee makers and a microwave. Everyone knows that the best education happens over a cup of coffee and a hot danish.

STI is still working on their lighting. The front room uses about one kilowatt of standard fluorescents driven by coil/capacitor ballasts. While the Trace 2012 powers this deeply reactive load, it really discharges the battery rapidly. Ken and Johnny are working on increasing the efficiency of their lighting with the help of Sardo Sardinsky from Rising Sun Enterprises in Basalt, Colorado. The lighting specs given on the table are for the stock, unmodified fluorescents.

The remainder of the loads are real lightweights and are easily powered by the system. Items like laptop computers and answering machines really consume very little energy in comparison with a large photocopying machine.

*STI System Cost*

| System Component | Cost | % |
|---|---|---|
| Ten 45 Watt Photovoltaic Modules | $2,700 | 29.3% |
| Thirty ED-160 Nicad Cells (480A-h @ 12 V) | $2,070 | 22.5% |
| Trace 2012 Inverter SB/DVM | $1,480 | 16.1% |
| Zomeworks TrackRack | $900 | 9.8% |
| Heliotrope CC60C PV Control- 60 Amp | $315 | 3.4% |
| Wire & Cable | $275 | 3.0% |
| Fused Disconnects 30 Amp | $235 | 2.6% |
| Steel Poles for mounting PV Arrays | $225 | 2.4% |
| Misc. Hardware | $215 | 2.3% |
| Cruising Equipment Ampere-hour Meter | $195 | 2.1% |
| Heinemann 250 Amp DC Circuit Breaker | $175 | 1.9% |
| Conduit, Electrical Boxes & Raceways | $145 | 1.6% |
| Battery Box materials | $85 | 0.9% |
| Mains Panel (Service Entrance) for RE use | $85 | 0.9% |
| Inverter and Battery Cables | $60 | 0.7% |
| Cement | $45 | 0.5% |
| Total System Cost | $9,205 | |

**System Cost**

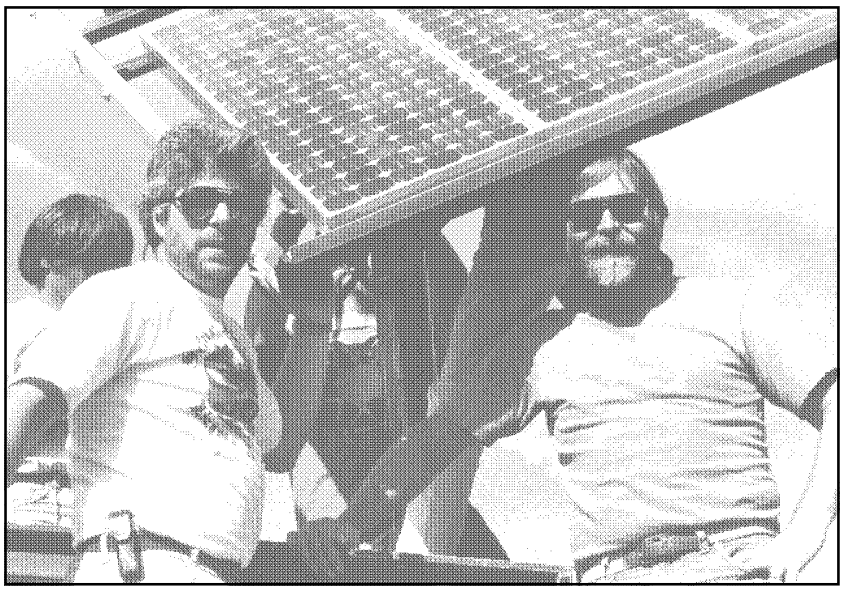
Well, since the entire show was donated, the system cost STI virtually nothing. Even the labor was donated by the willing and eager crew. To give you an idea of the real costs involved, I have worked up the following cost list based on the retail price of the donated gear.

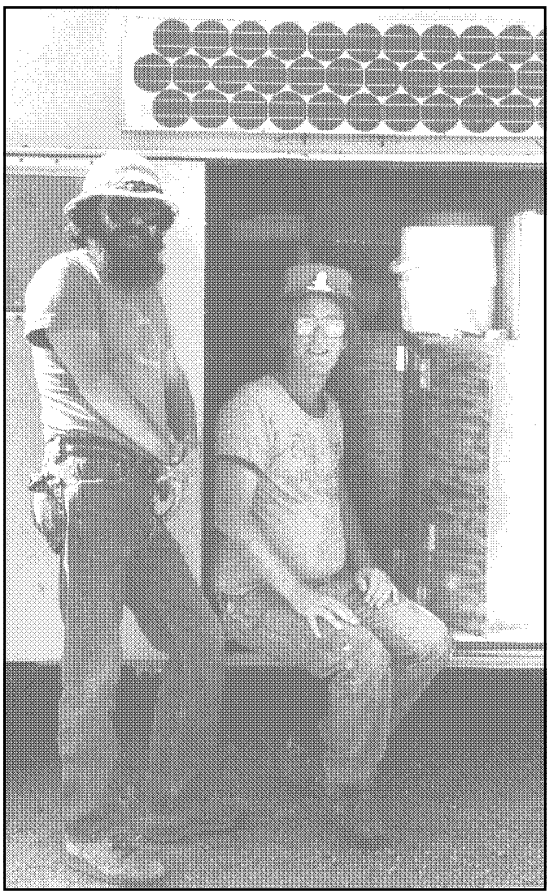
**The Solar Tech Experience**

There is a lot more going on at STI than listening to an instructor drone on and on for hours at a time. Sessions are closer to visits over the dinner table than conventional classroom scenes. Education at STI is more of a discussion than a lecture. Every morning's classroom session is followed by an afternoon lab session demonstrating the principles learned that morning. After a week of intensive (we worked hard) learning, then comes the second week of actually applying what is learned. This is critical. Not only does actually installing a real life system cement the concepts firmly in mind, but also makes everyone aware that nothing is as cut and dried as it appears in the classroom. Every real world installation is filled with unique compromises and glitches. In a large part, becoming adept at renewable energy systems means being able to deal with each system as an individual entity. Each system has its own requirements and problems. STI realizes this and teaches how to solve these problems.

And there is still more. During the class we converted a Maytag washer using one of Wattevr Works' Guzzle Buster Kits. We measured the power consumption of the unmodified washer on four different inverters. Then we converted the washer to a super efficient 120 vac setup and ran it again on the same four inverters. In fact, Jim Forgette at Wattevr Works is telling the truth about his washer conversion kits. The Maytag used one-third as much power after conversion. The STI students did the conversion and made the measurements. They said that Wattevr Works' conversion documentation and instructions were the best they have ever used. The STI students not only learned the innards of a washer, but also the importance of reducing power consumption, and maybe most importantly the ability to use and understand instrumentation. And the washer conversion was only one ring of a multi-ringed circus. Over in the back room another group lead by Kent DeVilibiss converted a Marvel vaccine refrigerator with a super-efficient Danfoss compressor transplant. And in the center ring…

The part I enjoyed the most happened in the evenings when the whole group invaded a local restaurant and discussed renewable energy over dinner. You can always tell those with the Spark because they are still talking



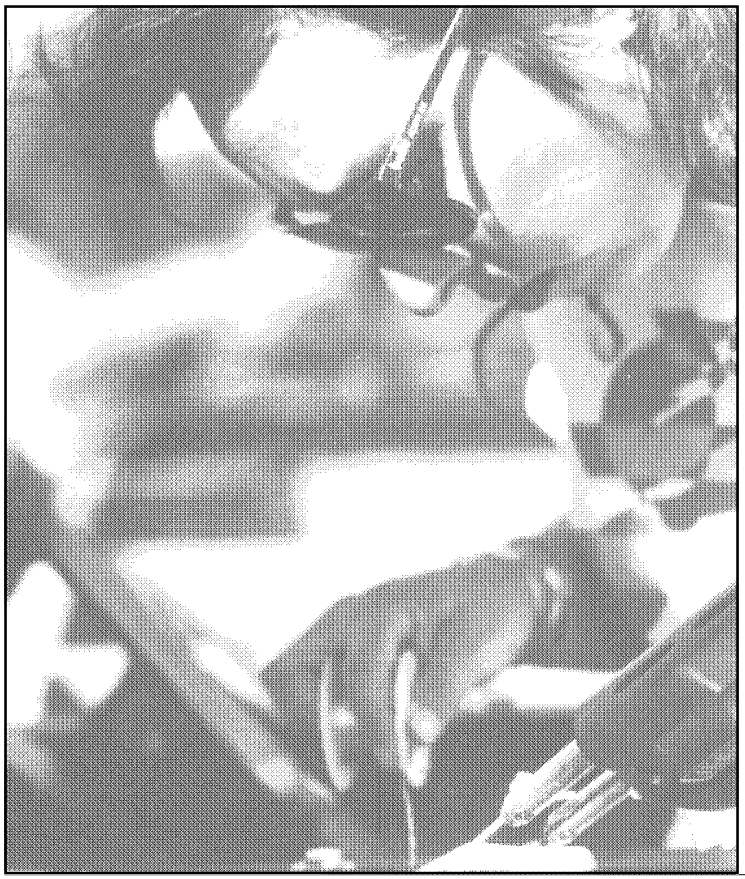


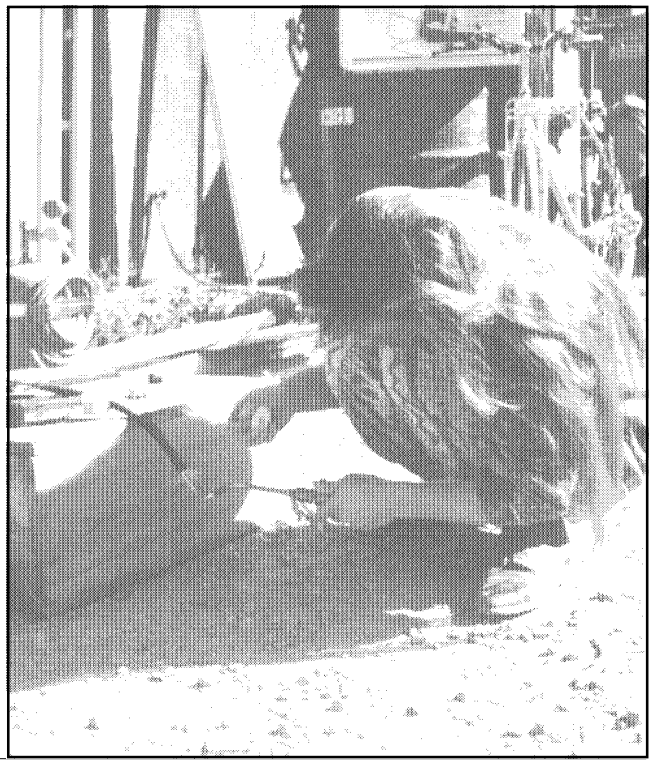
Above: Johnny Weiss (left) and Ken Olson (right) in front of the six panel Zomeworks tracker. Photo by Chrissy Leonard.

Right: Richard Perez (left) and Paul Wilkins (right) take a break beside Paul's VW Bus–a mobile PV system. Photo by Chrissy Leonard.

Below Left: Flash Trevor-Crampton solders connections on a Spire PV module. Photo by Chrissy Leonard.

Below Right: Connie Engeler-Bowers solders a heavy copper terminal to an inverter cable. Photo by Sam Landes.





shop after hours. The discussions were far-reaching and comprehensive. Often they would slop over into the next morning's classroom sessions. One discussion in particular, on working with renewable energy as a profession, was so fruitful that I have assembled the material into an article in this issue (Careers in Renewable Energy on page 36).

Paul Wilkins was on-hand and video taped the entire proceedings. At last count, he had recorded over 22 cassettes. Paul is going to edit these and there are plans to make them available to whomever is interested.

Ken and Johnny are now offering Solar Technology Institute memberships. A membership supports STI, a nonprofit educational venture, and the members get the STI newsletter. All STI memberships, except the low income model, come with a free one year subscription to Home Power Magazine. This is our way of helping Ken and Johnny with the essential work they are doing.

**Conclusions**

I'm having trouble writing a conclusion here. Things at STI don't conclude–the beat goes on. After I left, Don Harris from Harris Hydroelectric showed up for a week-long course on microhydro. I wanted to stay for that course as well as the following courses on solar home design & construction, solar remodeling, passive solar design, heating, and solar building skills. A short course in low-tech hydrogen production and use is being scheduled. And I hear that Mick Sagrillo may be teaching a wind course in the Spring…

**Access**

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STI: Ken Olson and Johnny Weiss, Solar Technology Institute, POB 1115, 358 Main Street, Carbondale, CO 81623 • 303-963-0715.

**Companies who donated equipment to STI:**

*I usually don't include free plugs for companies that can and do afford to advertise within these pages. I am making an exception for companies who donated gear to STI. In my opinion, these companies deserve recognition for their donations. So here's a list of the companies that care enough to support the Solar Technology Institute:*

12 Volt Products
ASES
Bobier Electronics
Burns-Milwaukee
Chronar
Clevelab
Electron Connection
Flowlight Solar
Gates Battery
Harris Hydro
Heart Interface
Heliotrope
Home Power
Hoxan
Independent Power & Light
Kyocera
Levelg
McCracken Solar
Midway Labs
NREL (SERI)
Photocomm
Photron
PowerStar Products
PVIEA (Mark Fitzgerald)
Rainshadow Solar
Real Goods
Remote Power
Rising Sun Enterprises
RMS Electric
SAB Nife
Sandia National Labs
SCI
SES
Siemens
Skyline Engineering
Solar Box Cookers Int'l
Solarex
Solarjack
Solar Pathways
Solex
Solopower
Sovonics
Star Solar
Sun Amp
Sunnyside Solar
SW Technologies Institute
Synchronous Design
Thin-Lite
Trace Engineering
Trojan Battery
Utility Free
Vanner
Wattevr Works
Zomeworks

Above: the old water pumper converted to an electric generator waiting for a breeze. The box two feet below the tower's top houses the slip rings. Photo by Dick Linn.

# Hybrid PV & Wind System

Dick Linn



The power lines did not go past our property when I started building back in 1980. This was due to one of those quirks in pole routing. They were nearby, but the power company wanted the usual pound of flesh to reroute their lines to me. So I decided to do without. I built the house and later the two story barn with borrowed generators and Coleman lanterns. Three or four years later the power company decided to reroute their power lines and now I have two different lines crossing our property, for which they paid me $1 per pole! It was too late by then though, as I had gotten stubborn and had decided to make my own power someday. So we lived with propane lights and refrigerator.

**Reworking a Waterpumper to Make Electricity**

In February of 1990, the Windmill went up. This is an old waterpumper of indeterminate origin that my neighbor, an old friend who wheels and deals for a living, found for me. I converted it to a DC generator by liberal use of old bike parts, as I had a barn full of them. I replaced the wood mainshaft bearings in the wind machine with Harley tapered-roller, fork neck bearings. I mounted a motorcycle rear brake drum and sprocket just behind the fan on the wind machine's mainshaft. This drives a jackshaft with two sprockets on it, which in turn drive the generator. The brake also provides a means of stopping the fan when servicing. The overall gear ratio obtained was about 1:23. This speeds up the generator to where it will do some useful work. I figured on a maximum fan speed of about 100 rpm. This is using the original multibladed fan with a diameter of 8 feet.

The generator itself I made using four permanent magnet Lucas bike alternators. I assembled these inside a piece of round tubing, and machined the end plates to house the bearings, and made a shaft to fit through the assembly. These alternators originally put out about 10 Amps. @ 12 Volts at 3000 rpm each. They came off Triumph motorcycles from the Sixties. By wiring their output in series-parallel I ended up with 24 Volts with a hoped for output of 20 Amps max. I used a full wave bridge to rectify the output from each of the alternator stators to get DC power to recharge to the batteries.

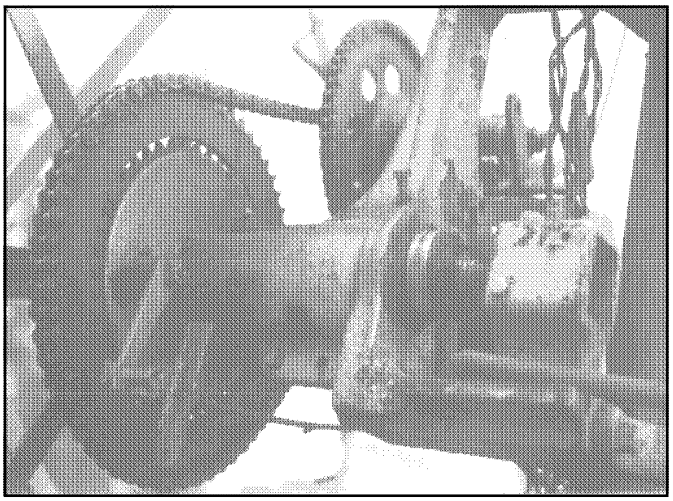
Slip rings are necessary to carry the current from the rotating wind machine to the stationary tower. I built the slip rings up on the main vertical pipe that runs down through the main turntable bearing. This pipe pivots with the head of the wind machine. First I slipped two pieces of

black plastic water pipe over the pivot pipe. Then I slipped two pieces of copper tubing over these. These were a snug fit over the plastic pipe pieces. I then drilled a hole through the sandwich and used insulating washers with a lip to insulate the screw from the inside pivot pipe. I ran the wire from the bridge rectifier (which is mounted on the head) down inside the pivot pipe and fastened it to the screw on the inside of the pipe. This has worked out fine. The actual brush is a piece of 3/8" copper tubing that is flattened out and rubs against the bands on the pivot pipe. The first set of brushes didn't hold up too well. They made erratic contact, so on the second set I backed them up with a piece of hack saw blade which acts as a flat spring. It's not too strong a spring but gives just enough tension to keep the copper strips in constant contact with the rings. The slip ring and brush assemblies are inside an electrical box with a hole in the top which the pivot pipe enters. The box is mounted to the lower bearing of the pivot pipe about 2 feet from the top of the tower.

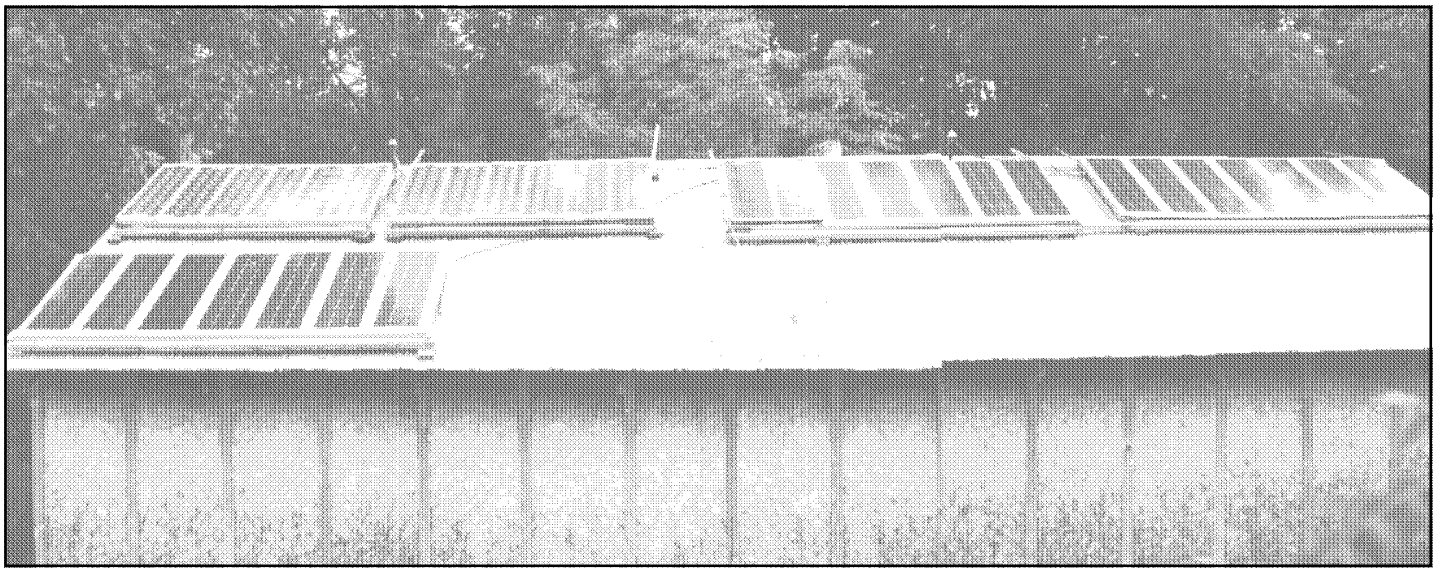
When I first turned it loose, the rig didn't respond to light winds. Supposedly these old mills produce power at very low wind speeds. I ran it this way for several weeks and could get about 6-7 amps at high wind speeds. I have no way to actually measure the wind's speed. I estimate wind speeds around 20-25 mph as high and around 10 mph as light.

**Modifications and Acts of God**

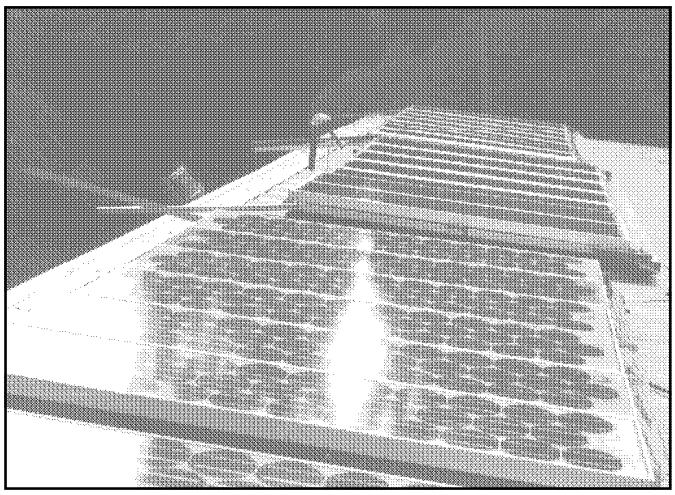
After the windmill had been up for about 3 weeks, we had a big storm blow one night. I clocked 17 Amps, just before the fan blew off! Never use a 2 piece mainshaft on your fan. Sooner or later it will come apart and put your fan in the trees! I pounded out the bent blades and had a friend machine a new shaft out of stainless steel. I put it back up in the wind with only two alternators. This cut down my potential output, but lowered the overall resistance to rotation. This has worked very well in light winds, giving me 6 to 7 Amps as a high, and putting out 2 Amps regularly on our breezy spring days. It won't put Jacobs out of business, but if you have a lathe and more time than money, it'll work. You could use some sort of permanent magnet motor for the generator; I just used



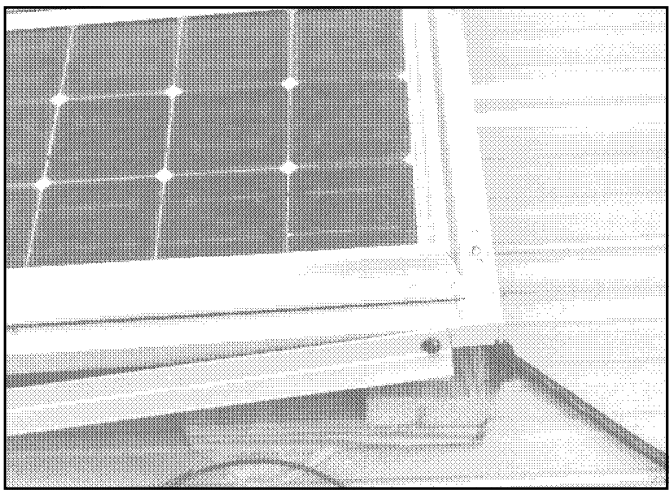
Above: chain drive from windmill to alternator. Gear ratio is about 1:23. Photo by Dick Linn.



Above: photovoltaic modules on the barn's roof. There are twelve ARCO 16-2000 PV modules and twenty-one ARCO M52 PV modules on this roof. Photo by Dick Linn.



Above: "Sunlight on PVs" Photo by Dick Linn.



Above: frame for the M52 laminate. Photo by Dick Linn.

what I had.

**Solar Power Enters the Picture**

About this time the used ARCO 16-2000 modules appeared on the market (Spring '90) so I decided that some solar panels might help cut down on the engine/generator running time. I bought four and hooked them up temporarily in the yard. It became apparent that solar power was indeed practical in upstate New York, contrary to what all the "experts" would lead you to believe. After using the ARCOs for a month or so, I decided to spring for 8 more of them, bringing the total to 12 panels wired for 24 VDC. The panels were put on the barn roof, 350 feet from the house and the batteries.

**One Year Later**

After having the system up for a year, I wanted more generating capacity. So when I saw an ad for used ARCO M52s in Home Power, I called Harding Energy Systems and ordered a total of 19 more Panels without frames. Earlier I had ordered two framed panels from Photocomm. After hunting around for something suitable to frame the M52s, I found some aluminum extrusion that could do the job at a friend's trailer sales and service shop. The extrusion was originally intended to be used for mounting sliding windows in custom vans. I was able to buy this in 20 foot lengths. I made the frame pieces with 45 degree cuts on each end and slid them around the panel like a picture frame. The panel fit in a groove in the extrusion embedded in silicon seal. I used flat, 2 inch, 90 degree corner braces to tie the corners together. I popriveted the brace to the extrusion. This made a fairly rigid structure. When mounted to the angle iron frames on the roof, the panels were securely supported.

It cost me about $4.00 per panel to mount the panels. The angle iron frames are painted and are adjustable for inclination. I first tried to use series strings of six of these panels to charge my 24 Volt battery bank, but was only getting about 18 Watts per panel in that configuration. So I tried using seven M52s wired in series and then got about 22 Watts from each panel. This was closer to what Harding Energy Systems said I should get.

After I had mounted the first two strings of panels, I got a letter from Harding saying that they had been receiving complaints of low output and that if I would send copies of invoices they would send me one additional panel at no extra charge for every three I had already purchased. This seemed to back up my own findings of low output. So I sent for my four warranty panels and ordered three more so I could make one more string of seven panels. This gave me a total of three strings of seven M52 panels each, plus the twelve ARCO 16-2000s. That's how I ended up with a barn roof that's more PV than tin!

**Battery Experiences**

When I first got the system on-line in the Spring of '89, all we had for batteries were two Interstate 85 Amp-hr. marine batteries. They gave us a total of 85 Amp-hrs. at 24 VDC. We needed more storage capacity, but I had held off buying anything because: 1) I'm cheap and I hate to spend money, and 2) it seemed that I might get hold of some used Telco lead-acid batteries free for the taking.

After eight months the Telco deal fell through, but by then I'd read enough about nickel-cadmium batteries in Home Power that I decided I had to have some. The problem was money, as usual. As it happened, a customer my company was doing a job for (we install and service industrial audio and video equipment) had a contract to refurbish New York City subway cars. Each car had a

battery bank of twenty-five 140 Amp-hr. nickel-cadmium cells! At first it seemed there would be no problem taking some of the used batteries off their hands for free. However, the idea got shot down at higher management levels due to the "Big Pockets" syndrome. Apparently these batteries are considered toxic waste when they are spent. As such, the company felt it could not get free of its liability unless they paid a toxic waste handler to take them away. So that battery deal fell through also.

By now I was desperate. I started checking all the places which used nicads that Richard had listed in HP#13. I started calling around and finally ran across one man who seemed sympathetic and told me to call back in a week or so and he'd see what he could find. Lo and behold I called back and he said that he had some used batteries that he'd sell. $5.00 for the lot, but I'd have to take them away. Needless to say, I did. They turned out to be thirty-nine 100 Amp-hr. nicad cells used for starting a diesel engine. This made a very nice 200 Amp-hr. @ 24 VDC battery bank. I had presumed that I would need 40 cells to make two 24 Volt strings, but Lon Gillas at Pacific West Supply said that 19 series cells per string would actually recharge better with the 31.5 Volts produced by the PVs. The 19 series-cell pack should still give around 24 Volts under load. In an earlier conversation Lon had been very helpful in giving advice as to what to look for when shopping for used nicads. These turned out to be in good condition and have been working fine.

**Living with Nicads**

I cannot praise nicads highly enough. You hook them up, check the water occasionally, and that's it. These cells sat at about 1/2 to 3/4 discharged through December and January last winter and never really got a full charge until late March. The nicads never complained. If you're working around them and accidentally touch them with your clothes, no sweat: alkaline electrolyte doesn't eat your clothes! Also the tops of them don't grow all the crud and corruption that lead acid types do. I keep mine outdoors in a weather protected box and the cold Northeast winter never bothered them. My advice is don't waste your money on the lead-acid experience!

If you can't afford to buy from the nicad recyclers advertising in HP, look around. Don't be afraid to ask people if they know where any of these critters may be living. It can't hurt to ask and you may be rewarded.

**One Year Later**

I ran the system on these batteries for one season and for sure did not have enough storage capacity. They would last me for about two to three days of no sun or wind. So I kept a look out for more nicads. I started calling around again and found another sympathetic source. The person I reached said to stop on down and talk about it. I did and he eventually showed me the pile of nicads and nickel-iron cells that he had taken out of service.

I'm always surprised by the interest people show in what I'm doing. This man is very interested in PVs as a charging source, but unfortunately could not use them in his application because of remote locations inviting vandalism.

Anyway, he had sixty 240 Amp-hr. nicads that were about ten years old and 89 nickel-iron (Ni-Fe) cells that were about 30 years old. About half of these Ni-Fe cells are 220 Amp-hr. capacity and the rest 100 Amp-hr. capacity. The Ni-Fe cells needed new electrolyte to restore their vigor. He told me that his company would have to pay $1.00 per pound to have the cells hauled away so he didn't feel that he could charge me anything for taking them. The nicads tested out at their rated capacity and the nickel-iron cells about half capacity. With a change of electrolyte the nickel-iron cells should get back to their original rated capacity. All this for free. He also said to keep in contact as they are continually removing these cells from service. This all adds up to about 900 Amp-hr. in nicad storage and another 250 Amp-hr. in nickel-iron. With this much capacity I have no need for a charge controller. I would like to have been more specific as to where these cells came from and give the individuals credit for their kindness, but considering the legal aspects of used batteries, I cannot.

I have tried to research the legal aspects of used batteries, especially nicads. The New York State Police informed me that as long as I was hauling these cells for my own personal use, the laws on hauling toxic waste did not apply. That means I can legally load them in my truck and haul them away. And it certainly isn't illegal to have them in your possession. The rub seems to be that the person that you get them from is responsible for seeing that they are hauled by a toxic waste hauler to a licensed disposal operation.

So if you find someone cooperative, just remember that they are very likely putting their job on the line for you.

**Auxiliary Battery Charging System**

The sun doesn't always shine in upstate New York, and my present wind generator doesn't have the capacity to carry us through the mid-winter months. To keep the lights lit, I built a gasoline powered charger much like that described in Home Power #2. In fact I started with an old Briggs & Stratton gas engine and Chevy alternator

mounted on a piece of wood, and a homebuilt Mark VI charge controller to regulate. This wasn't powerful enough to suit me as the 3 1/2 hp. engine wouldn't drive the 70 Amp alternator I had.

So I built another charging unit with a piece of steel channel iron for a base about 14 inch wide and 30 inch long that sits about 2 inches off the ground. On this I mounted a 1950 Royal Enfield 350cc single cylinder OHV (Over Head Valve) motorcycle engine. This is a dry sump engine with an integral oil tank. It probably develops about 15 hp. max, but runs at less than half speed in my application. This is connected to a Ford 70 Amp alternator by V belt. The engine is also connected to a motorcycle transmission by chain so that the engine can be kick started. The engine is bolted to the base with 2 inch angle iron brackets. I also mounted a set of old handlebars on a couple of pieces of 1 inch angle iron that stick up from the base 2 ft. or so. I mounted the throttle and spark retard levers on these. They're also handy to hang onto while starting the engine. I mounted two 24 Volt muffin fans on brackets to cool the engine and these seem adequate for winter use. If I used it in the summer, it might overheat unless I mounted more fans, but it's not needed in summer. This unit will crank out 30 Amps @ 24 VDC no problem. I did nothing to the alternator to run it at 24 volts, I just used the 24 Volt version of the Mark VI to control it. Oh yes, this unit starts on first or second kick even at 5 below zero!

The reason I used this engine was: 1) I already had it, it had been given to me for free, and 2) I wanted to try an OHV engine. Theoretically they are more efficient than a flathead type engine like the Briggs &Stratton. This seems to be borne out by my gas consumption.

I don't have any hard data, but I know that it's running longer on a tank of gas than my old Briggs & Stratton unit, which I keep around for backup. We also have an old Briggs & Stratton 120 vac generator we use when I need to run the power saw or my wife Jill needs to vacuum.

**Wind In The Future**

I am gathering the components of a larger wind generator now, so that someday I won't need to use the gas powered rigs anymore! It will use a truck generator and a 60 foot freestanding tower I've already picked up.

**Waterpumping**

There was an old hand-dug well on the property when we bought it so I cleaned it out and we are using it. We pump the water to the storage tanks on the hillside above our house and let gravity flow the water down to the house. To pump the water to our storage tanks, I use an old piston water pump with a Ford 12 VDC generator as a motor. The elevation is about 25 feet. This works fine with a resistor in the feed to the field coils to drop the voltage to the fields to about 6 volts. It's hooked up to a float and sense switches so that it turns on when the level is low and off when high. I built a small logic circuit to do this. It also senses battery voltage and when voltage rises above about 29 Volts it will automatically turn on the pump and let the upper limit switch turn it back off. I won't print the schematic for this circuit yet, as once and awhile it still blows an integrated circuit! The motor draws about 8 Amps when pumping. My next project will to be to use one of these generators on my lathe as a motor.

*Where the Bucks Went*

| System Component | Cost | % |
|---|---|---|
| 12 used ARCO 16-2000 PV Modules | $1,800 | 45.9% |
| 19 used ARCO M52 PV Modules | $1,069 | 27.3% |
| Old waterpumping windmill w/ 32 ft. tower | $300 | 7.7% |
| 2 used ARCO M52 PV Modules | $300 | 7.7% |
| 500 ft. 00 gauge used aluminum cable | $200 | 5.1% |
| PV panel framework materials | $120 | 3.1% |
| Motorcycle parts to convert windmill | $75 | 1.9% |
| Misc. disconnects, breakers, etc. | $50 | 1.3% |
| 39 used NIFE 100 A-h Nicad Cells | $5 | 0.1% |
| 60 used NIFE 240 A-h Nicad Cells | $0 | 0.0% |
| 89 used Edison 220 A-h Nickel-Iron Cells | $0 | 0.0% |
| Total System Cost | $3,919 | |

*Where the Power Goes…*

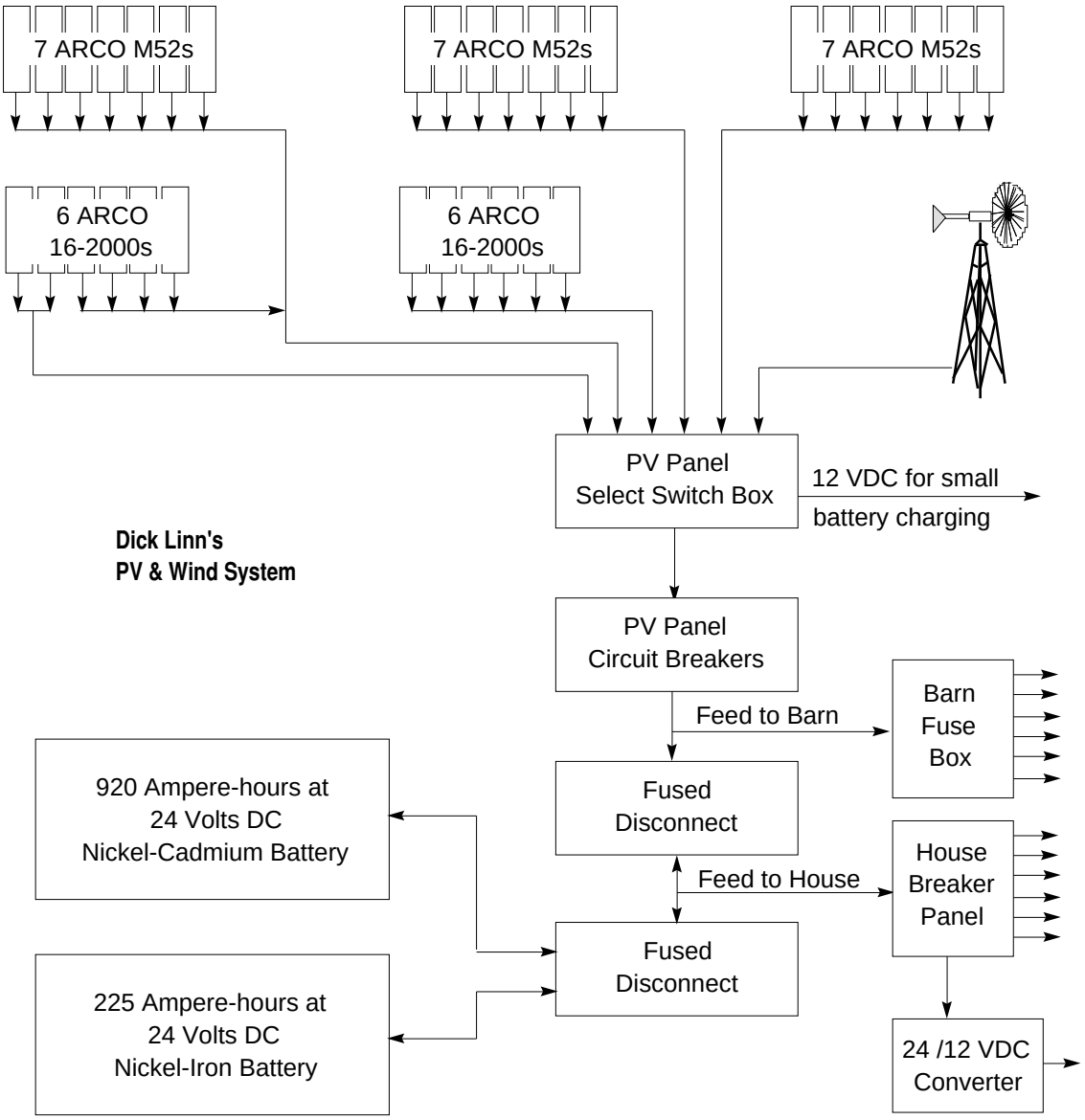
| # | Appliance | Watts | On Time Hrs/day | W.-hrs. per day |
|---|---|---|---|---|
| 2 | 40 W. DC Fluorescent Lights | 40 | 6.5 | 520.0 |
| 1 | 13" Color TV and VCP | 125 | 3.5 | 437.5 |
| 2 | Barn Incandescent Lamps | 100 | 1.0 | 200.0 |
| 1 | 24 VDC wringer washer | 175 | 0.5 | 87.5 |
| 10 | Various Incandescent Lamps | 40 | 0.2 | 80.0 |
| 1 | 24 VDC piston water pump | 190 | 0.3 | 57.0 |
| 1 | 30 W. DC Fluorescent Light | 30 | 1.5 | 45.0 |
| 2 | PL DC Fluorescent Lights | 13 | 1.5 | 39.0 |
| Total Energy Consumption in Watt-hours per day | | | | 1466.0 |

Total usage measured on our Cruising Equipment

Ampere-Hour meter: 60 to 80 Ampere-hours per day.

**How It Goes Together**

The PVs are on the barn roof on homemade angle iron mounting frames. They are wired up in four banks. Originally, there were just the two frames of ARCO 16-2000s, twelve panels total. These were wired so that you could select, with a switch in the barn, the output from one bank of six panels, one of four panels and one of two panels. Additionally the bank of two could be switched to 12 VDC production which appeared on an outlet below the switch bank. All this switching turned out to be needlessly complex as I only use the 12 Volt option for charging. With the addition of the M52s, I modified the switching setup so that there is one bank of six 16-2000s on a switch. I then wired one bank of four 16-2000s in parallel to one frame of seven M52s, both on a second switch. This leaves one bank of two 16-2000s still switchable for 24 or 12 Volt operation on a third switch. The remaining two frames of M52s are wired to a fourth switch which I added when the new panels went up this year. All the panel outputs then go to circuit breakers before going to a main fused disconnect that leads to the house. The 12 VDC output option was added so that I could charge bike or car batteries directly from the panels.



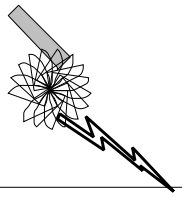

There are also Volt and Amp meters on the board. This fused disconnect feeds the underground line that runs to the house, 350 feet away. This line is currently 2 gauge aluminum. I hope to upgrade this transmission line someday in the future. At the house there is a junction box where the line from the barn ties in to the feed to the battery box which is located behind the house. I will probably move the batteries to the barn now that I have added more cells. There is a disconnect at the battery box to take them off line. The line from the battery box reenters the house and feeds the main breaker panel and the homemade 24 to 12 VDC converter. The main breaker panel is a standard 120 vac type with Square "D" breakers. The 12 Volt line also goes to the main panel but only feeds one circuit now, for the TV and Video Cassette Player. All other circuits are 24 VDC. The house was wired to NEC code as closely as possible and we use standard 120 vac switches and outlets. I just make sure that they are used at 1/4th their UL rating. As we don't have an inverter there's no problem with power mixups.

Above: My able assistants, Tyler (3 yrs.) and Ryan (6 yrs.) and our original 200 Amp-hr. at 24 VDC battery made up of NIFE nicad cells.
Photo by Dick Linn.

When the time comes to get an inverter, I may possibly use the bright orange isolated ground outlets for 120 vac.

**The Bottom Line**

When I started building my "cabin" in the woods back in 1980, I had no inkling that I would someday be part of a family of four. I was content to have my escape from the world and I didn't mind if I did my reading with an Aladdin Lamp. I had it in the back of my mind that I wanted to make my own wind generator from a water pumper and felt sure that it would make all the electricity I'd ever need. Washing machines and night lights never even entered my mind! I've learned a lot these last two years and owe most of that knowledge to these pages right here. HP appeared on the scene in my life at just the right time. It has kept me from making some mistakes and led me to building a system that is fulfilling the needs of our family. I've also had a lot of fun and enjoyment building the system and I doubt if I'll ever be "finished" with it! I think it's a good experience for my boys. Only time will tell for sure, but I'm willing to bet I have the only three year old in the county that can say and knows what "electrolyte" is. And the six year old knows the difference between a nicad and a car battery!



# Prologue to Methane Gas

Al Rutan, the Methane Man



Why gas? What's so good about gas? One could make an argument *ad hominem* and simply say, if gas weren't such a good idea, why is it so abundant in nature. It

**Gas Use**

What about flammable gas? Why consider it? For those of us who spent much of our youth chopping wood to heat and cook at home, the idea of gas is like something from paradise. The idea and the experience of merely turning a valve to have instant flame without all the "bitching" and complaining involved in "go get that wood!" is amazing.

Almost everyone likes the ambiance around a campfire on an outing with friends. But for the day to day fuel needs, we wish to have it as "automatic" as possible, and for being controlled by a thermostat, gas is unsurpassed.

It is clean and uncomplicated. Clean? Yes, clean. There is no soot that collects in a chimney from the burning of methane gas. Does it need to be vented? It should be, if at all possible. The fumes from any type of combustion should be considered suspect.

Potential problems from the burning of methane are minimal. If the combustion is complete, what is produced is carbon dioxide and water vapor. Yet we have no practical assurance that combustion is always as perfect as it could be.

An interesting note historically is the fact that the Indian government some 40 years ago pushed the development of homestead production of methane because so many people were going blind from the effects of burning cow dung for fuel. Our early pioneers had similar experiences from the burning of buffalo chips. Burning raw manure should always be considered a "no-no."

Low-tech methane production information comes from both India and China–two countries with vast populations, huge pollution problems from waste, and an immense need for fuel, which isn't readily available.

**At Home**

Our interest stems from the fact that homestead methane production is one more way to unplug from a utility company and provide access to energy, which substantially contributes to the quality of life.

So, one has to have the heart for it. Unlike electricity, that is for all practical purposes quite mechanical, gas production means tending to living things, like a flock of chickens, a band of sheep, or milking goats. For abundant gas production, there needs to be a sensitivity to the special needs of the microscopic creatures that produce flammable gas as their waste product. This means providing for their basic wants and–don't laugh–giving them a measure of love. All living things–plants, animals, and people–require love in order to flourish. This need extends even to living creatures that can't be seen with the naked eye.

A person we know who had a methane system one day went up to his tank and gave it a good hefty kick as an experiment. The gas production stopped immediately, and started slowly again only after some time had passed.

Because one must assume responsibility for the care of a colony of living entities, producing gas to burn has another dimension some may need to consider before undertaking such a venture.

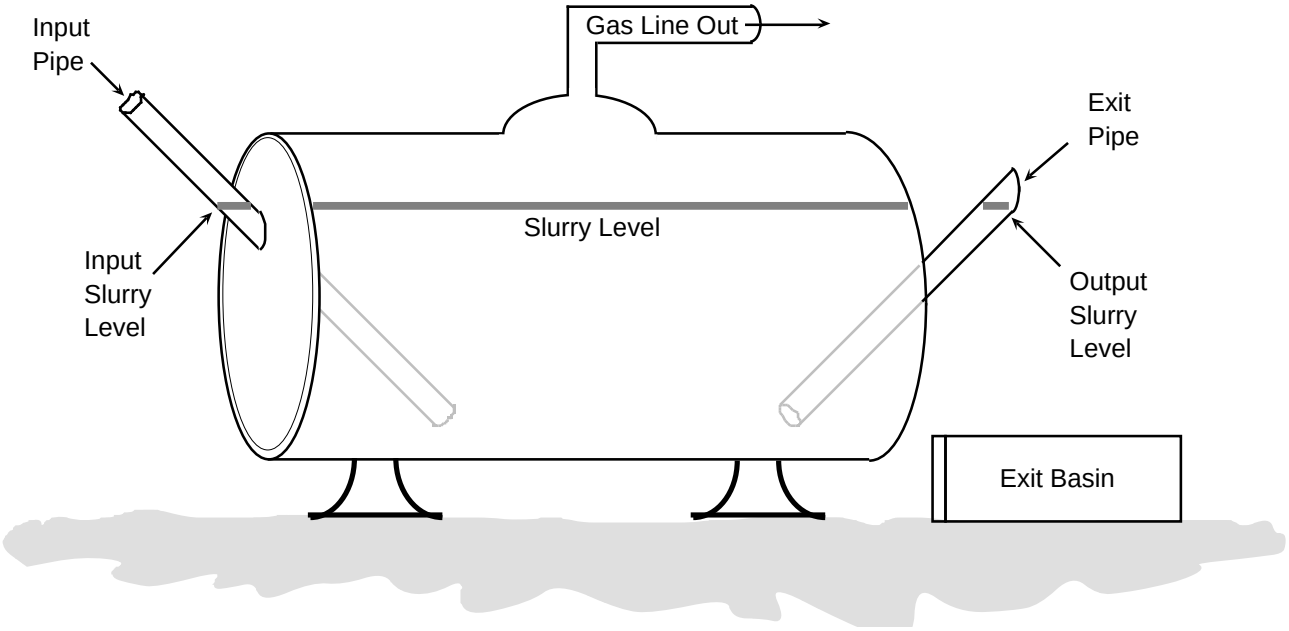
The advantages of gas are many-fold. It is so easy to use. It is so controllable. It is relatively easy to store. It can be used automatically. It will even run your vacuum cleaner if you put the methane gas through a fuel cell which will turn the gas directly into electricity. Plus, it is so clean–no soot, no creosote, no ash, and no chopping. What more could you ask?

**Making and Using Methane Gas**

Methane is a natural gas. The reason it's called "natural" is because it occurs in nature everywhere. It can be the gas found in a swamp or marsh, the gas found in a coal mine, the smell coming from a septic tank or sewer line, or the gas sold to us by a utility company under the title of "natural gas." The product is substantially the same, $CH_4$.

We've heard that methane is odorless, and it is. Sewer gas we know is not. So what is the difference? When the process that produces gas is underway, there are a variety of gases produced at the same time. All such gases result from micro-organisms feeding upon organic matter and producing gas as a waste product. Methane,

*METHANE TANK CONCEPT SKETCH*




which is odorless, is one of them. Hydrogen sulfide, which is smelly, is another. It is hydrogen sulfide which gives us the characteristic sewer gas or "fart" smell.

When these gases are encapsulated in the ground over a long period of time, the smell is purged, leaving an odorless gas. The sewer gas smell can be removed easily from the mixture by simply bubbling all the gas through calcium carbonate, which is simple barn lime, and thereby scrubbing it so to speak. The gas becomes odorless. The gas companies re-introduce an odor to odorless gas before selling it as a safety measure so that our noses can detect "loose gas" that could be potentially dangerous.

All these burnable gases are produced by anaerobic organisms feeding upon organic matter. To say they are anaerobic means they only live when air is excluded from the space in which they are functioning.

They are the same organisms that cause us to have intestinal gas. Each time a warm blooded animal defecates, some of the gas producing organisms are contained in the feces. This is why it can be said that methane occurs virtually everywhere. Wherever air is excluded from the decomposition process, the production of methane and accompanying gases is likely to occur.

Stories are legion about a bunch of guys with nothing better to do than ignite the intestinal gas of one of their particularly "gassy" buddies, and then being amazed at how flammable the experiment was.

The micro-organisms that produce flammable gas are temperature sensitive. They want body temperature in order to function most effectively. In people that is 98.6°F. In a chicken or a pig the body temperature is 103°F. So right around 100°F is the optimum temperature for the process to work most effectively. The action can occur at lower temperatures. As the temperature drops so does the rate at which methane gas is produced.

People will sometimes ask, "Why can't I use the gas off my septic tank to burn in a stove?" The typical septic tank swings through such wide temperature fluctuations, the amount of gas produced is minimal. Each time a toilet is flushed with cold water, the tank goes into "shock." Each time some warm wash water from a bath or shower flows into the tank, it becomes more active until the next shot of cold water. Such tanks are ordinarily in the ground, which stays at a constant 50° to 55°F. The ground is a constant heat sink, draining heat away from the tank. About all one gets from a septic tank, by way of gas, is enough to cause an unpleasant odor. Because the temperature cannot be maintained at the required working level, such tanks have to be pumped from time to time. The solids cannot be efficiently digested and so keep building up.

**Key Considerations**

It is the concept of a tank which offers us the most practical approach to the task of harnessing the production of methane. Liquid within a tank gives us two immensely important features–transport and the exclusion of air. Both are essential for maximum production.

Some methane production occurs in such places as an ordinary barnyard manure pile. The center of the pile is without air and with the heat generated by the pile some methane gas is bound to be produced. If we want to harness the concept, we will need a great deal of gas. A solid pile to give us what we would need would have to be, literally, a small mountain. In a tank, it's an entirely different matter. It is much easier to have the tank "just bubbling away" so that the amount of gas collected in a short time can be significant.

**Key Questions**

How much gas do I need? That will determine how much gas must be produced. Next is, how much material do I need to produce this amount of gas? The third question is, how large must the equipment be to produce and store this amount of gas?

Gas is thought of in terms of cubic feet. We can all visualize a cubic foot–12 inches square in each direction. The amount of gas within such a space of 12 inches square is determined by the compression of the gas. Fortunately, when we are working with methane, we are talking about only ounces of pressure–just enough pressure to push the gas to the burner, whether it might be a stove, water heater, or refrigerator.

For "home-made methane," our pressure regulator is not any more complicated than a heavy rock on an inflatable gas holding bag, or the weight of a solid yet expandable gas holder floating in liquid. It's not very complicated.

**How Much Gas Does One Need?**

To estimate the amount of gas needed, the average family of four burns somewhere around 200 cubic feet of gas a day. This covers the combined tasks of cooking, heating space and heating water. Obviously, individuals can trim this amount considerably by using efficient appliances–such as flow-on-demand water heaters, and high-efficiency space heaters.

The best way to get a handle on this information is to look at the amount of consumption listed on the utility bill of some family you know and then observe their lifestyle.

**Processes of Gas**

We say that the liquid provides transport. That transport is two-fold. Obviously, we must transport the material to the tank. Equally important, yet not so obvious, is the transport of the micro organisms to the material or vice-versa, so that the material can be digested by the life forms. Within the digestive tract of a warm blooded animal, this action takes place by peristalsis. We imitate this transport by very gently moving the contents within the tank from time to time.

**Concerning The Tank**

A simple paddle mechanism works the best. Some systems re-circulate some of the gas to provide movement, but this has proven to be less than satisfactory. Often inorganic material is stirred from the bottom of the tank–material such as sand and small rocks if they are present–and the living organisms are injured in the process. The best method is a slow mixing action with a paddle of some sort. The paddle may be on a horizontal axis or a vertical axis. It merely has to move the material very gently a few times each day.

The exclusion of air is essential to have the process work. While we know that even water contains some air–otherwise how could fish breathe–once the activity of gas producing bacteria becomes established, even the air is mostly excluded.

The tank must be closed so that new air is not able to enter. This is done effectively by having both the fill pipe and the exit pipe extend below the water line. So, air exposure to the tank is limited to the surface of the water level in both the fill and exit pipes.

In the past much discussion focused on whether the tank should be horizontal or vertical. It is the consensus that when the tank is horizontal rather than vertical, it can work more effectively. (Note the illustration on pg. 25.) The reason is that the fill and exit pipes need to be spaced as far apart as possible. Then the material entering the tank has greater exposure to the activity within the tank before being moved near the exit pipe.

The gentle stirring action needed, of course, mixes up everything. Yet if the new material is forced to "migrate" some distance before reaching the exit pipe, then the micro-organisms will have more time to feed upon it before it is replaced by incoming material.

How big should the tank be? This is determined by how much material is available to the tank on a daily basis, and ultimately how much gas one wants to generate.

**Production Mixture**

The input for the tank needs to be a mixture of manure and carbon material. Carbon material is ordinarily understood as waste vegetation, but it can't be just anything. It needs to be something that when soaked in water for a few days becomes very soft. The bacteria don't have any teeth. They have to "gum" it.

Hardness can be misleading. A carrot seems hard, but if soaked long enough it turns to mush. Grass clippings, on the other hand, contain a quantity of lignin, that cellulose fiber that makes wood very "woody." Anything with a high

content of lignin will not work well in a methane tank. Straw for the most part is acceptable. Hay is not.

Even such things as ordinary newspaper work well. Although newspaper at one point was wood, the lignin has been broken down so that when the newspaper is soaked for a day or so, it turns to mush–good stuff for our purposes. The bacteria want a mixture of 30 parts carbon to 1 part nitrogen. Manure is nitrogen rich–about 15 parts carbon to 1 part nitrogen, so manure needs to be balanced with more straight carbon material. This ratio isn't a critical proportion and the process still functions, but 30 to 1 is the ideal.

**Potency**

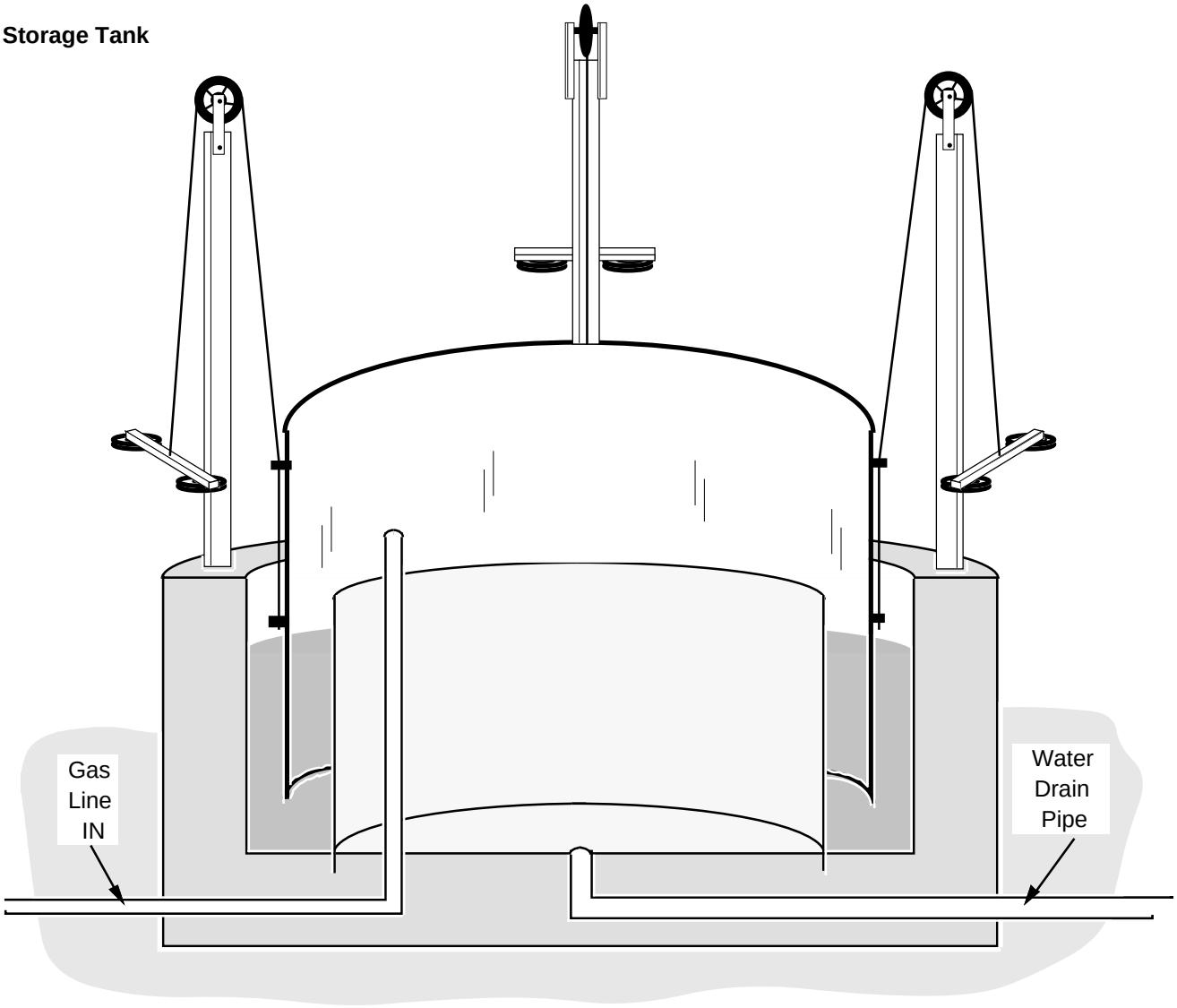
The ability of manure to produce gas varies from animal to animal. Chicken manure can be especially potent. I have observed as high a yield as 10 cubic feet of gas from each pound of naturally moist chicken manure which was mixed with some finely ground spilled feed.

Hog manure usually yields about 4 cubic feet per wet pound. Cow manure usually yields about 1 cubic foot of gas for each pound of fresh manure. The reason there is such a difference is that much of the methane potential has already been released when the waste goes through the digestive system of a ruminant. There is usually so much of this kind of manure, using it is still worthwhile. Another good feature of the process is that raw manure is changed into something which is aged and totally acceptable to be placed on growing things. With any quantity of raw, green manure, this is not the case.

**Sizing the System**

Having established that we need around 200 cubic feet of gas a day, we need to set about designing a system that

**Gas Storage Tank**



will provide this. How much is 200 cubic feet? Visualize an inflatable bag that is six feet wide, six feet long and six feet high, and you're seeing a space of 200 cubic feet.

If we say that a mixture of manures will give us 4 to 5 cubic feet of gas per pound of naturally wet manure we are going to need about 40 to 50 pounds of manure a day. We would need even less manure if we use chicken waste. These forty pounds are going to be mixed with some type of additional carbon material, to which water, preferably warm water, will be added to give us a "slurry." This will most likely be about 15 gallons of bulk. Visualize the content in three five gallon buckets.

**Size of the Tank**

It is generally a rule of thumb that the size of the tank needs to be 40 times the size of daily input. This means that when 1/40th of the volume of the tank is introduced at the input end then 1/40th of the volume will exit the overflow end simply by being displaced. Allowing some space at the top of the liquid for the gas to collect, the tank should be about 50 times the size of daily input.

Sewage plants that employ the methane process–and many do–like to have a holding time of 90 days. In other words the preference is to have the tank 90 times the size of the daily input. The purpose of this is to totally destroy any potential pathogens. That length of time within the tank does exactly that. Periodic inspections by the various health departments around the country keep a check on such activity and find consistently that the 90 day holding time accomplishes this goal.

Within a 40 day holding period most of the pathogens are eliminated. Because we are not dealing primarily with human feces (although this material may be used with animal waste) the longer holding time is not as imperative. Within a 40 day time span the greatest amount of gas is produced. In a period longer than 40 days, the gas production begins to slow down considerably.

We need a tank that is 50 times the volume of the daily input of 15 gallons, or a 750 gallon tank. Obviously, a 1,000 gallon tank would be ideal to take care of extra demand for production or additional material input.

**Tank Choice**

A 1,000 gallon discarded milk bulk tank would be ideal. Because bulk tanks already have a system for cooling the tank, this system could be easily adapted for holding the temperature of the tank at 100°F. rather than cooling it. One type has the "radiator" already built-in.

The fact that the tank is stainless steel is also an advantage because it would extend the life of the tank considerably over ordinary sheet metal. The acids within the mixture do not work rapidly on the tank, but they will deteriorate it over an extended period of time.

Originally, I had an ordinary 250 gallon fuel-oil tank that I used for demonstration purposes. It lasted for several years. It finally rusted through, but considering the fact the metal was relatively light gauge to begin with, the tank served well. Because oxygen is excluded in the process and the pH must be kept at neutral, the deterioration of the tank was not rapid.

Another great feature of a milk bulk tank is the fact it already has a mixing paddle as part of the tank's design. All access ports above the water line would have to be sealed air tight for effective gas production and, more importantly, just common sense safety.

**The Gas Holder**

Regarding a gas holder, one may use a solid vessel open at the top filled with liquid into which another solid vessel open at the bottom is placed. The gas pushes the top unit up out of the liquid as the gas is produced (see illustration on pg. 27).

The simplest type of gas holder is an expandable bag. It can be something like a waterbed mattress upon which a weight is placed to produce enough pressure to send the gas to the point where it is used–a burner of some type.

One may use simply a vinyl of some type, but the best type of material is a nylon fabric that is impregnated with vinyl–not laminated, but impregnated–which becomes exceedingly durable. If this inflatable bag is placed inside a "silo" of some type, then there is a measure of assurance that the bag is not going to be punctured. The people who work with the nylon impregnated vinyl–one of the trade names is Herculite–seal it by a process of electro-statically welding it. Using an ordinary adhesive may not work because methane has a tendency to dissolve a number of adhesives

**For Now**

The process of making methane gas is relatively simple if one is attuned to the basic needs of the process. They are: the right balance of material, the right temperature, and the exclusion of air. Given these three conditions, the methane process is virtually unavoidable. The trick is to be sensitive to the fine-tuning of each of these requirements. As we continue with more methane articles in Home Power, we will do just that.

**Access**

Author: Al Rutan, POB 289, Delano, MN 55328

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monitor battery and charging rates. **$3** shipping

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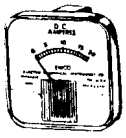
10-16 volts, 22-32 volts.
**Equus** Digital 8-18 volts **$38.**



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0-5, 0-10, 0-20, 0-30, 0-60.

**INDUCTION Type DC Ammeters.**
Just hold against wire to read. No connections.
**Model 763**; 0-30 amps **$20.**
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### DIGITAL AMP HOUR METER

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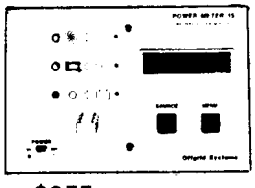
*A fuel gauge for batteries.* Keeps track of how full the battery is by counting the AmpHours drawn out and replaced. **$179.** **$6** shipping. New PLUS & PLUS 2 meters are also available at low prices.

### POWER METER 15



by Offgrid Systems. Monitors Battery, Engine Generator, Inverter, Solar Charging and displays AC Volts, DC volts, Amps, Amp-Hours, Watts & Watt-Hours.

**$255** One meter does it all. **$6** shipping
32 amp shunt **$38,** 250 amp shunt **$38**

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9-15 volts expanded scale, 0-15 amps, 14 amp circuit breaker all wired and mounted on a 4"x7" black aluminum flush mount panel. Looks like SCI Mark III PV charge controller. Made by SCI. $99 value **$49**

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### TRACE inverters

**New** Model **812** is 800 watts! Low Cost. 2000 watt, 12v Lightly used unit for **$895.** 2500 watt, 24v used unit for only **$1148.**

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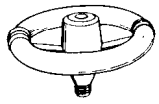
Attractive **Model 193** fixture is $18^1/_8$" x $2^1/_4$" x $2^7/_{16}$" with switch. **15 watt** 1.3 amps **$32**

**Model 108** **22 watt** 1.6 amps **$32.** Screws into a regular socket. Nice for table lamps or ceiling light.



## PERMANENT MAGNET DC MOTORS

**1/4 - 3/4 HP,** 1200 -3600 rpm, 12 - 36 volt, continuous duty, reversible. **$10** ship $275 value. **$145**
**TANG SHAFT**, similar to above. $200 value. **$49**
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**$6** shipping. **12 Volt**

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|---|---|
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| 3/4 Full 46" | **$54** |
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## REFRIGERATORS

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Only uses about 1.5 gallons of propane a week.

### SUN FROST electric

*By far the world's most efficient*
**12 cu. ft.** ($1700 value) **$1572** DC or AC
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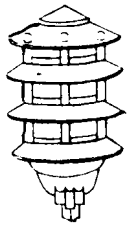
**19 cu. ft.** ($2650 value) **$2250** AC
Available in 12, 24 volt DC or 120 volt AC
Sun Frost refrigerators are recommended for an energy efficient home or for an energy independent home

## AC COMPACT FLUORESCENTS

Reduce electric bills by $25 to $60 over the life of these lamps. They are 4 times brighter, last 10 times longer and give off much less heat compared to regular incandescent bulbs. Sizes of bulbs available include: PL 5, PL 7, PL 9, QL 9 PL 13, QL 13 & QL 22. Fits standard sockets.

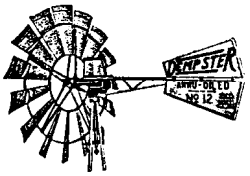
**$3** shipping
**11 watt** lamp with replaceable PL 9 bulb and adapter. **$10**
**15 watt** lamp with replaceable PL 13 twin tube bulb and adapter. ($18 value) **$11**
**15 watt** PAGODA fixture with replaceable PL 13 bulb. Use for patio, garden and path lighting. 6" x 11". Base threads onto 1/2" pipe. ($45 value) **$32**



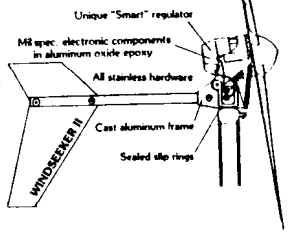
**PAGODA**

**12 volt Ceiling Fan** 45", Reversible. Variable Speed. 0.3 - 2 amps. **$10** ship **$155**

## WIND POWER



**WINDMILL WATER PUMPER**
**CATALOG $4**




**WINDSEEKER II WIND GENERATOR**
12 volt, 250 watt **$795**
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19 lb., 5' blade, fits 2" pipe tower.
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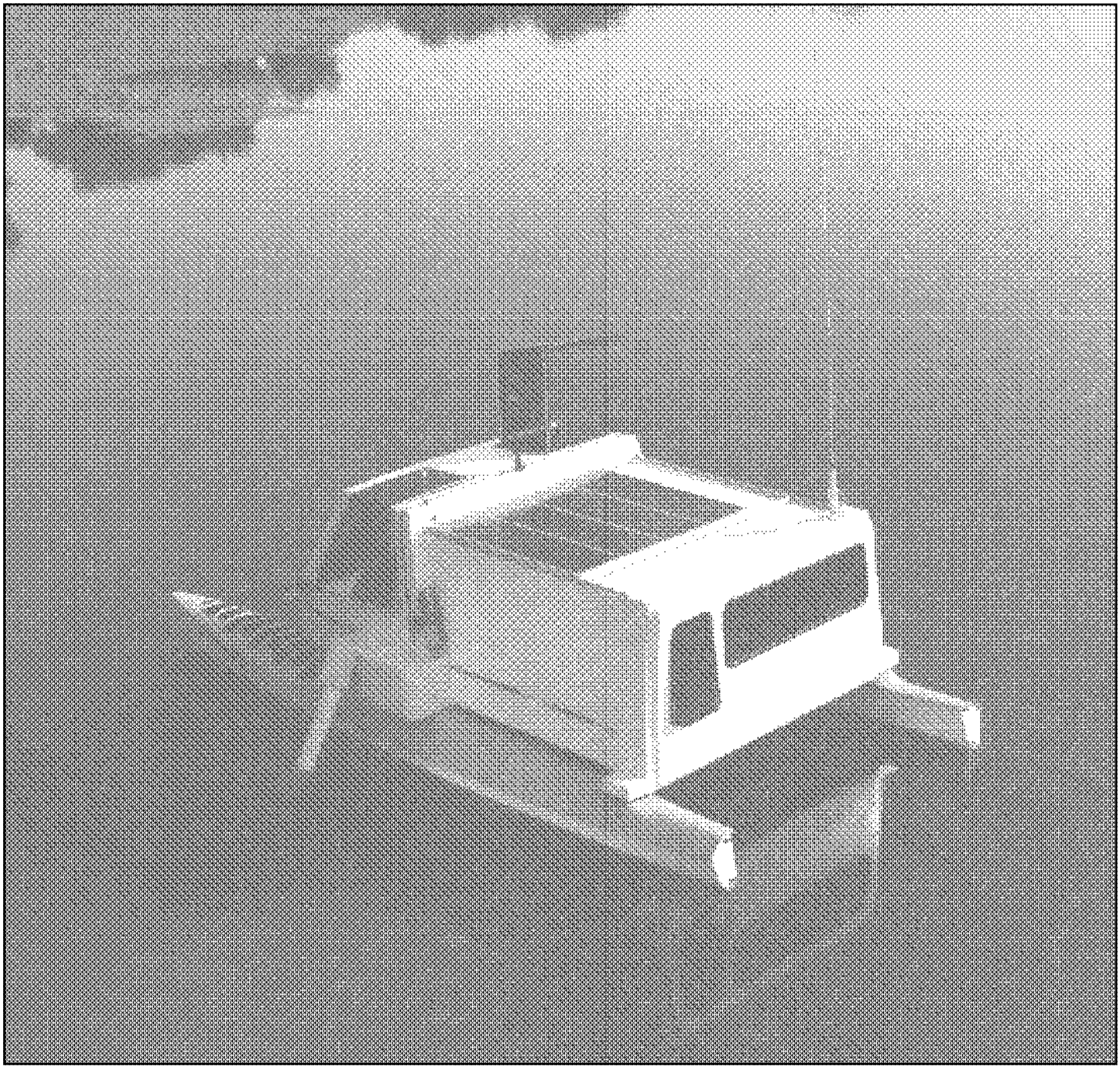


Above: The "Neah Bay," a solar-powered boat, proudly launched on Long Lake, Minnesota, 10 August 1991. Notice the four solar modules, gull-wing doors, and Loran C antenna. The motor pod is lifted to the 'shallow water' position. All windows are tinted acrylic plastic. Photo by Harmut Ginnow-Merkert.

# A Solar-Powered Boat

Hartmut Ginnow-Merkert



In 1989 I had to decide what to do during my one-year sabbatical, a much-needed break from my teaching duties at the Minneapolis College of Art and Design. My desire to make a meaningful contribution to an environmental issue combined with my interest in boating and solar energy resulted in the decision to develop a solar-powered boat.

**Background**

My background in mechanical and electronic engineering and industrial design provided the foundation, and a week of volunteering at the second American Tour de Sol provided me with additional wisdom concerning solar energy systems and components.

At the Tour de Sol, I also noticed what I considered a basic problem in the area of solar-powered products: People need to identify with a product in order to accept it. It is not good enough to make the product work; it also has to motivate, stimulate, trigger people's curiosity, attract them, and make them want to own and operate such a product. They need to see and understand the benefits of using a product.

Many of today's solar-powered consumer products fail this test, because they don't relate to the consumers' physical and psychological needs. I decided to test this idea in the design of my own solar-powered boat.

I had not built a boat before, and work with fiberglass was out of the question, so I decided to purchase a used hull and build the superstructure out of plywood.

It seemed logical at that time that a catamaran (twin hull) design would be a good start. Catamarans are fast and provide plenty of area for solar modules.

A used Prindle 16 was purchased, and I had to make the painful decision to disassemble it to a point where it could never be used as a sailboat again. Together we enjoyed one more beautiful day of sailing on a lake nearby, a good breeze propelling the boat at hull speed.

Sailing is an environmentally sound way to enjoy our natural resources, but wind is a form of energy which fights you every inch of the way. It throws you into the water, surprises you by randomly choosing directions, and abandons you just when you need to go home. Masts need to be stepped, and get entangled in power lines. Miles of ropes snatch at your feet, booms try to break your skull, and heavy keels make your life miserable. Some people like the challenge, those who don't, drive power boats–and pollute.

I don't think of solar boats in terms of competition, however. Solar boats provide an alternative for those who want to enjoy a lake or river, who are too lazy to paddle or sail, and who want to keep the environment clean for our children. Solar boats are great for wildlife observation, cruising, reflecting, and relaxing.

**Construction**

The Prindle was dismantled, the hulls were switched and mounted to the original aluminum extrusions with wedges that would hold them perpendicular to the water surface (they normally point slightly outward).

My design was to defeat comparison with existing types of vessels: it was not to be a sailboat without a mast, or a power boat without power. I wanted the boat to look different, something people hadn't seen before. Connotations of other high-tech products wouldn't hurt, and as speed was not an issue, I was not interested in a speed-boat look. A box would be just fine.

I decided not to use a rudder, instead I would use two electric motors, one on on either side of the boat. This would reduce the component count and increase the reliability. By running the motors at different speeds and varying their direction, the boat would become highly maneuverable. The controller could be a joystick, or even better, a knob whose movement the boat would duplicate: forward, reverse, rotation left or right.

There had to be a roof for the solar modules, so what could I put under the roof? I decided to turn this part of the boat into a sleeping cabin, for extended camping trips. The front portion would be the cockpit, to be designed more like the interior of a van than that of a conventional boat. There just had to be two gull-wing doors. I consider the roof a desirable feature, because it protects from ultraviolet radiation and rain. It also prevents fishing. I don't fish.

Solar boats have yet to be defined. Many exist, mainly in Europe and Japan, and there are many different layouts. A solar boat has a "personality" defined by the relative size of each of its main components: solar generator (PV modules), battery storage, and motor(s).

The size of each of these components depends on the type of use the boat is intended for. The two corner stones are:
(a.) a boat which is used once a week for a few hours. This boat needs lots of battery storage capacity and very little solar generator area, because the boat has six days to recharge. And
(b.) a boat that's used for racing purposes and needs to go for hours or even days at peak power. This type of solar boat will need a huge solar generator and very little battery storage.

There is an infinite number of combinations, each with a special purpose or type of use.

The configuration I chose uses four M75 Siemens Solar modules (with room for two more), two 100 Ampere-hour deep-cycle, maintenance-free lead-acid batteries, and two electric trolling motors operating at 24 V and 30 A The

electronic “glue” consists of an SCI battery charger (Photocomm) and two Curtis PMC 1203A motor controllers. Additional electronics had to be developed. The two motors are mounted on pods which extend from the battery boxes sideways. These pods are driven by two Warner Electric electromechanical linear actuators with potentiometer feedback.

A rotary switch in the control panel sets one of 4 programmable positions (maintenance, shallow water, deep water, trailer). An electronic circuit compares these settings with the actual motor pod positions, and power is fed to the linear actuators until they reach the desired position. A future extension of this concept includes the possibility of interfacing this circuit with the depth finder, so that motor position adjustments are automatic.

The human interface uses a tandem Penny & Giles T-bar potentiometer with a tandem rotary potentiometer on top. These pots were used because they are hermetically sealed and very reliable. They are also very expensive.

More electronic devices were used to make the boat more exciting and to distract onlookers from asking questions about the top speed (5 mph). These devices include a mobile phone which allows me to conduct my business from the boat, a Loran C/Depth Finder unit, and a compact disk player.

The boat was built during the spring and summer of 1990 and test-launched 10 August 1990. It took another few months to finish, test, and rebuild some of the electronic components, and the boat finally became operational in May of 1991. It has been on the water and operated flawlessly for over 100 hours.

**Experience**

The boat was named “Neah Bay” after a Makah Indian Reservation on the Northwestern corner of Washington’s Olympic Peninsula. It generated some interest among the local media (two video clips on the local TV news, a radio interview, two newspaper stories). Many individuals commented about the boat, and I was invited to speak at several schools. A local high school is exploring possibilities to start a solar boat design competition.

It was my intention to hold the first American Solar Boat Regatta in Minnesota, June 91. This attempt failed, because many of the prospective participants couldn’t get the funding at a time when the Gulf War and the recession made many corporations reluctant to sponsor this event. Solar boat regattas have been conducted in Europe and Japan for several years. Solar boats are now commercially available in Germany.

So far I have not been able to attract investors to start a solar boat business here. Obviously it is easier to see the need for solar boats in Europe where environmental pollution and public pressure have turned many lakes off-limits to gas-powered boats. Those among us watching the development of environmental issues in this country should be able to see the advent of similar restrictions on the horizon, restrictions which may severely hurt a boating industry unprepared for change.

I will continue to pursue this project. Stage 2 will see the redesign of this boat for production in fiberglass, with simplified mechanical and electronic functions. It should retail for around $8000, seat four adults, reach a top speed of six mph, provide a range of three hours at full speed (no sun), and an unlimited range under sunny conditions at speeds of up to three mph. This boat would allow fishing and be a real attraction at a lakefront resort.

You want to know what I’d really like to do? Be among the first few people to cross the Atlantic Ocean in a solar-powered boat. Hello, anybody else out there?

**Access**

Hartmut Ginnow-Merkert, 1840 Lakeview Terrace, Orono, MN 55356 • 612-473-8699

# Water Electrolyzers

L. E. Spicer



The wind blows freely over the hill behind our house turning an old Jacobs wind charger. This is the power source that we use to split the rain water that flows off our roof. Above the set-up cost and maintenance, making hydrogen is a free ride. For wind and water are free and nothing else is used up in the process.

**Inside the Electrolyzer**

Electrolyzers make hydrogen and oxygen from water by electrolysis. In Home Power #22, page 32, our hydrostatic column was explained. Here I would like to give drawings that more clearly show the water electrolyzer and the arrangement of multiple electrolyzer cells in a common liquid electrolyte as brought forth by patent #4,382,849 and used by Hydrogen Wind, Inc.

Figure 1 is an exploded view of the basic one cell electrolyzer. You can see in the drawing that it is simple in construction. It consists of a positive and negative electrodes #44 and #20, a separator box #16, within a pressure retaining housing #22.

Hydrogen and oxygen are divided out of the water by the use of a microporous membrane #18 configured into the separator box illustrated by Figures 2 and 3. The hydrogen and oxygen as separate gasses rise out of this box and separation is maintained by the divider plate (#56 in the upper part of Fig. 1).

A multiple of these cells can be wired together to equal an available DC power source. This, however, must be done in a certain way. If a number of electrolyzer cells were just wired together in a common electrolyte, the electricity would simply enter on the first positive electrode and pass through the electrolyte and exit on the last negative electrode, ignoring all the cells in between.

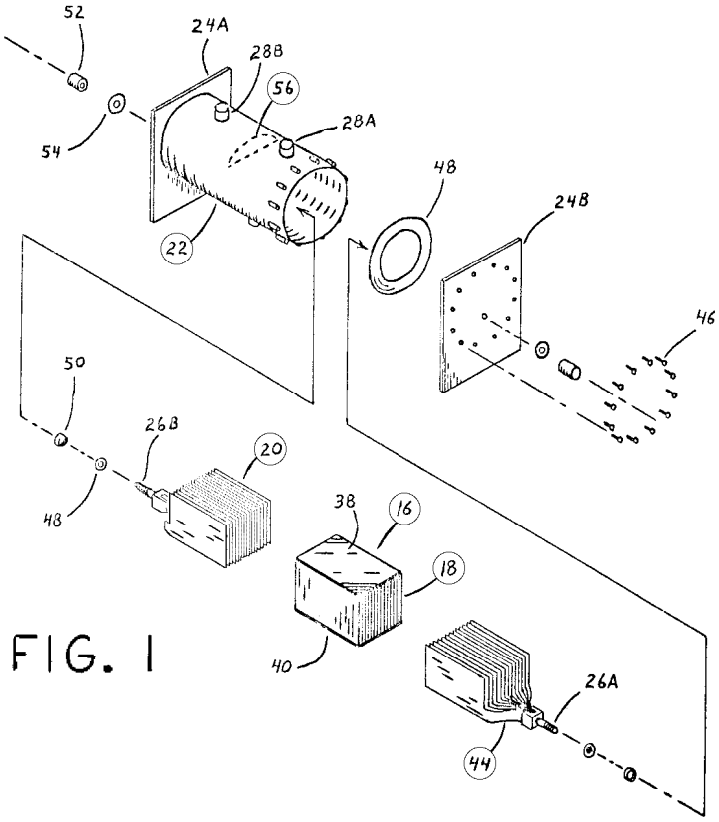



FIG. 1

FIG. 2

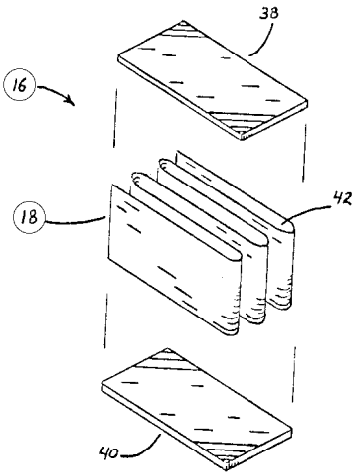
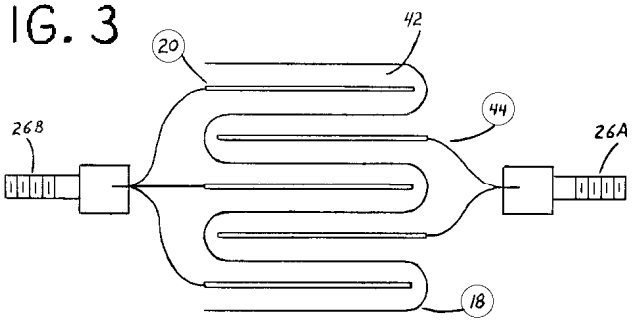



FIG. 3



**Gas Traps**

This shunting of the current can be avoided by using gas traps and electrolyte channeling as shown by Figure 4 and 5. The gas traps (#30 of Figure 4) consist of plastic tubing that hold a pocket of gas to prevent the flow of an electric current.

FIG. 4

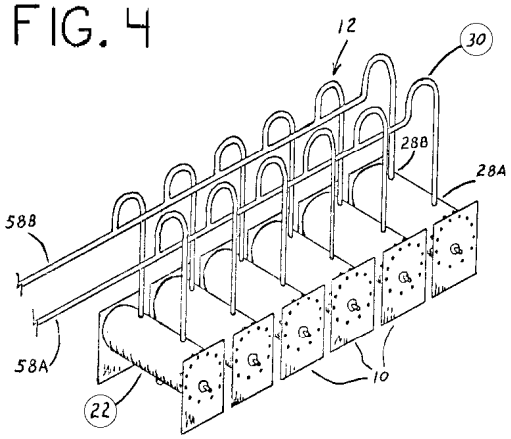
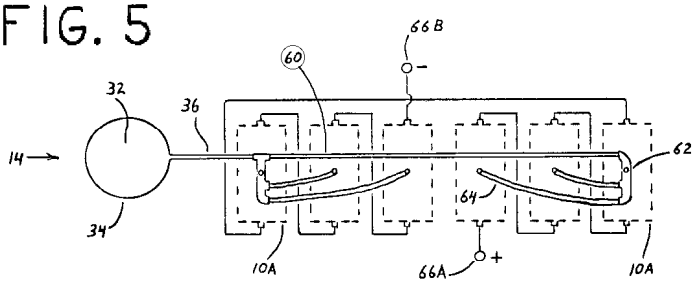



FIG. 5




**Electrolyte Channeling**

The electrolyte channeling (#60 of Figure 5) is also plastic tubing so arranged that the greatest resistance to shunt current through these tubes is at the cells of the highest potential. Electricity therefore, will take the path of least resistance, which is straight through each cell.

In addition to this, each electrolyzer must be spaced apart from each other to avoid electrical contact and must rest on a plastic or non-electrical conducting surface.

**Access**

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# Careers in Renewable Energy

Richard Perez

After the day's work was done at the recent Solar Technology Institute PV seminars, we'd gather at the local pub for food, brew, and mostly for talk. These BS sessions turned out some incredibly fruitful information. The best of the lot concerned the business aspects of renewable energy. Everyone saw an industry emerging from infancy. Everyone wondered where the opportunities were for immediate and meaningful work.

**In days gone by**

A renewable energy (RE) industry was a dream ten years ago. A dream kept alive by the dedication of Mom & Pop Solar Companies, a few rural systems, and a hopelessly hi-tech scientific establishment. The RE products performed poorly or not at all. Everything was far too expensive. The watchword was, "The energy of the future…"

Well, much has changed in ten years. Products have developed from expensive curiosities into cost-effective alternatives to nonrenewable energy sources. We learned much from ten years of applying these systems. We have high-efficiency devices like inverters, power point trackers, and controls. We have long-lived batteries, and super-efficient appliances. Each small breakthrough by itself may seem trivial, but the sum of all these small victories has given us working, reliable, and affordable RE systems. We have the technology to make renewable energy work today. The tech level of the RE industry reached critical mass about five years ago with the development of the 90%+ efficient inverter.

It was the grass-roots users who put it all together into workable, affordable systems. Each manufacturer, designer, and dealer saw only part of the picture. It took some thirty to fifty thousand users to really find out what worked and what didn't. Over time a dream became a real industry. Mom & Pop Solar grew. They grew from one partner working out to support the dream into having several employees.

**The RE Biz Scene Now**

There are now somewhere between thirty and fifty thousand nongrid connected renewable energy systems inside the USA. New systems are growing 30% annually. This means around ten thousand new, nongrid connected, RE systems next year. Next year's system buyers will spend over seventy million dollars on RE equipment and services. Sounds like a market looking for an industry to me. Once again, the users are light years ahead of the industry that supplies them.

There are three major reasons why people buy and use home-sized RE systems: they are located an unaffordable distance from the utility grid, they don't like how the utility makes the power, or they want the self-sufficiency offered by an RE system. The best deals in country real estate are located beyond the end of the power lines. This fact alone has driven incredible expansion in RE businesses located on the U.S. west coast. People are objecting to the fossil and nuclear fuels (and their inevitable pollutions) used by the utilities. Concern for our environment is an increasingly popular reason for using renewable energy. Electric power has become essential in our lives and the idea of owning a renewable source is irresistible.

Market demand and technology have produced an industry serving RE users. It may be as small an item as a PV-powered walk light, to a mega system for telecommunications, to a fully electrified country home. The market is as diverse as the individual who use the power and their appliances.

This industry contains both old and new companies. Some folks have been in the biz as long as twenty years now. Others have started up this year. Our "in the RE business" database at Home Power shows 867 businesses now active in renewable energy. The industry can be broken down into four types of businesses: original equipment manufacturers (OEM), distributors, dealers, and service businesses. Let's look at each in turn and see where the opportunities lie.

**Original Equipment Manufacturers (OEM)**

These folks make the equipment we use in our RE systems. The list of equipment is long: PV modules,

inverters, controls, batteries, wind turbines, hydro turbines, instruments, efficient refrigerators/freezers, efficient lights, load centers and other products. With the exception of photovoltaic manufacturers, most of these companies would be considered small to miniscule by Wall Street standards. Many are still managed by their start-up crews. Just about every company with a useful, working product at a reasonable price is growing.

There are opportunities for employment within these established companies. Company workstyle varies from informal to ultrarigid depending on the company. In very general terms, most of these OEMs are new enough to still enjoy their work. This makes these companies exciting prospects for techies who want a career in renewable energy. And techie is the key word here. Many of the most successful companies are heavily involved with electronics. An engineering degree or equivalent knowledge will just get you in the technical dept.'s door at most makers of photovoltaics, inverters, controls, or instruments. If hard science is not your thing, then consider the myriad of other jobs in these companies. There are jobs like providing customer support in the form of documentation and on-line advice, the ever present job of sales, and the office work which no business escapes.

If joining an established manufacturing company doesn't appeal to you, then start your own. Many of the big names in this industry started on a dream in someone's garage. Names like Trace, Sun Frost, Heliotrope, Bobier, Bergey, World Power Tech, and Solarjack spring to mind. If you have invented a viable product, then think of manufacturing it yourself. See the article about Bernie Haines and his Solar Pathfinder for an excellent example of a small manufacturing business in the RE industry.

In many cases, the product is not a new invention, but a new way of combining old ideas into new, specialized modes. Consider the 12 VDC load centers used in many PV systems. These load centers are custom-made by small businesses for specific applications. They use off-the-shelf components assembled for a new and specific job. The renewable energy market abounds with product niches yearning to be filled. Products are finding new applications daily. For example, recreational vehicles can greatly benefit from PV and inverter technologies. Outdoor security lighting is now much less expensive if PV powered.

Don't let the fact that there is a dominant product already in the market scare you away. There is always radical room for product improvement as well as making it less expensive. We are nowhere close to the ultimate PV, inverter, battery, or control. New products from new companies keep RE technologies growing and vibrant.

**Distributors**

These businesses stockpile RE equipment in large quantities and distribute it to dealers and installers around the world. In some cases distributors also carry on product testing, offer engineering services, and provide technical support. A distributor may have from several to dozens of dealers who then in turn sell and install the products to the end users. In some cases, a distributor will sell only to his official dealers, and in other cases, a distributor will sell to the general public. The fact is the RE industry is just now getting out of diapers and into training pants. Five years ago the distinction between distributors and dealers didn't exist. There were too few businesses spread over too large an area to require specialization.

Now with the RE industry growing, many of the larger dealers are evolving into distributors. These are rapidly growing, labor intensive businesses. A distributor is a great place to learn from the experiences of many dealers who buy from that distributor. A distributor's employment requirements vary from technical, to computer, to office skills. Above all, the ability to effectively communicate is essential. If you don't like dealing with people, then this level of RE career is probably not for you.

Starting a distributorship from scratch is difficult. First of all, the startup is heavily capital intensive and requires experience within the industry–experience that takes years to get. The most successful distributors started out as dealers. As dealers, they have amassed the capital and experience necessary to become a distributor. Many of these pioneering dealers slid into becoming distributors without hardly realizing it.

**Dealers**

The dealers sell RE hardware to the end users. There are two types of RE dealers, those who install what they sell and those who don't install what they sell. An installing dealer will not only sell the system's components, but will also survey the site, estimate the system's loads, specify the type and quantity of hardware, and last but certainly not least, actually install the hardware.

Home-sized RE systems were invented by do-it-yourselfers and back-to-the-landers. These folks installed their own systems. Now that the pioneers have blazed the way, many people want to follow. Trailblazers are always a distinct minority. Most of the systems sold and installed by dealers in the immediate future will be installed systems. The majority of folks are no more likely to install their own RE system as they are to install their

own plumbing. At ground zero, where the hardware finds its final home, the RE dealership is changing from a sales business into a service business. Dealers who realize this will be years ahead of those that don't.

While there will always be a dedicated crew of homebrewers and do-it-yourselfers buying from mail-order businesses and from noninstalling dealers, most Americans will go for the service.

The installing dealer offers far more than a cheap deal on hardware. He offers his customer service. He travels to the customer's location and surveys the site for RE potentials. He discusses and notes each and every device that requires power from the system. He advises his customer how to conserve power, thereby reducing system size and cost. After thoroughly surveying the load, the dealer then estimates the quantity and type of power the customer needs. The installing dealer then specifies a specific set of RE hardware which will use renewable resources to generate the required power. Only then, do installing dealers sell their customers the hardware and install the hardware on site. The dealer works with his customer, showing him (or her) how to use and maintain the system. The dealer supports his customer should anything go wrong. In many cases, the installing dealer is a state-certified, electrical contractor and will help pass the system with the local electrical inspectors. If you are serious about selling and installing RE systems, then an electrical contractors license is mandatory.

The phrase "installing dealer" used to mean a single person business. Folks who started this way five years ago now have companies employing from three to dozens of people. Becoming an intern at an installing dealership is the best and fastest way to learn this business. Installing dealerships are so busy now that many will not hire those without hands-on RE experience. These companies are simply too busy to teach their employees the basics involved. Hands-on means just that, that you have installed several and/or lived with RE systems. If you don't have direct experience, then a job is hard to get (a BSEE doesn't help either). If you need an intensive course in the basics, then consider attending STI or Jordan Energy Institute and getting their certification.

The installing dealerships are the backbone of the RE industry. The future of renewable energy is determined by these installing dealers. The major question now is not *whether* we will use RE sources, but *how* these sources will be used. We can rent RE produced power by the kwh from a centralized utility, or we can have our own power company on site. If the decentralized path is our choice, then we need thousands of new installing dealers inside the USA alone. We need to be able to open the phone book in any town and find a choice of dealers who will sell and install a system.

If you can't find work with an established dealer, then become one on your own. This is how virtually every dealer gets started, he just starts. This industry is legendary for low-capital start-ups, so lack of gobs of money is not a problem. The field of RE is still so open that dealerships are easily obtained for just about any product. And the places to set up shop are endless. Currently the areas of Northern California, Washington State, Oregon, Alaska, Utah, Upstate New York, Western Massachusetts, Vermont, and Hawaii are all areas with far more users than dealers. Inside the USA, most systems are being installed in rural areas, so look for a location were remote land is available. Internationally, Australia is developing its own RE industries and interest is high in this immense country. Europeans are buying more RE equipment than ever before. All developing nations need access to RE technology. To this end, your customer may be a government agency making RE technology available to developing countries. Small things like solar cookers can make very big differences in people's lives and our planet.

Finding new customers is easy for an installing dealer. Your best source of new customers are the neighbors of the last system you installed. Your satisfied customers are your best salesmen. Start advertising with continual (don't miss an issue) small ads in the local buy/sell shopping paper that's given away free almost everywhere. Put an ad in the Yellow Pages of the local phone book. Go down to the local Hall of Records and get the names and access data for everyone who bought powerless rural property. Talk with local real estate agents who handle property beyond the powerlines.

**Service Businesses**

Much of the immediate work to be done is informational. Providing information is a service business, just as much as watering the batteries and greasing the wind turbine. Informational services are needed by the government, utilities, and aid organizations, not to mention the RE industry and users themselves. Renewables can now do far more than the public realizes. The industry could grow even faster if more people knew what is now possible with renewable energy. This is the type of informational job we have taken on at Home Power Magazine. As RE becomes more mature, schools will make it part of their programs. We need textbooks, instruction manuals, and educational videos that make children more aware of

renewable energy sources.

OEMs need market researchers to tell them what the consumer wants in a product. Dealers need information that leads them to new customers. Doing a good job of marketing demographics for the RE market is a full time time job that has yet to be filled.

As more professionally installed RE systems are sold, more folks will also buy maintenance contracts for their systems. Servicing and expanding existing systems will become a service business of its own.

**In the Future…**

We've reached the point right now where a solar walklight is cheaper than hiring an electrician to wire in a grid-powered light. Solar bus stop lighting is being done cheaper than running in the power. Utilities are looking into large scale implementation of all types of renewables. Home power systems are being installed faster than ever.

The potential of renewable energy is limited only by our imaginations.

I don't have a crystal ball. I can only look back over the last twenty years and see where we have been, and plot the course to where we are now. I see that we have the answers to serious energy, economic, and environmental problems. I see a powerful industry growing with each sunrise; I see a good place for a life's work.

**Access**

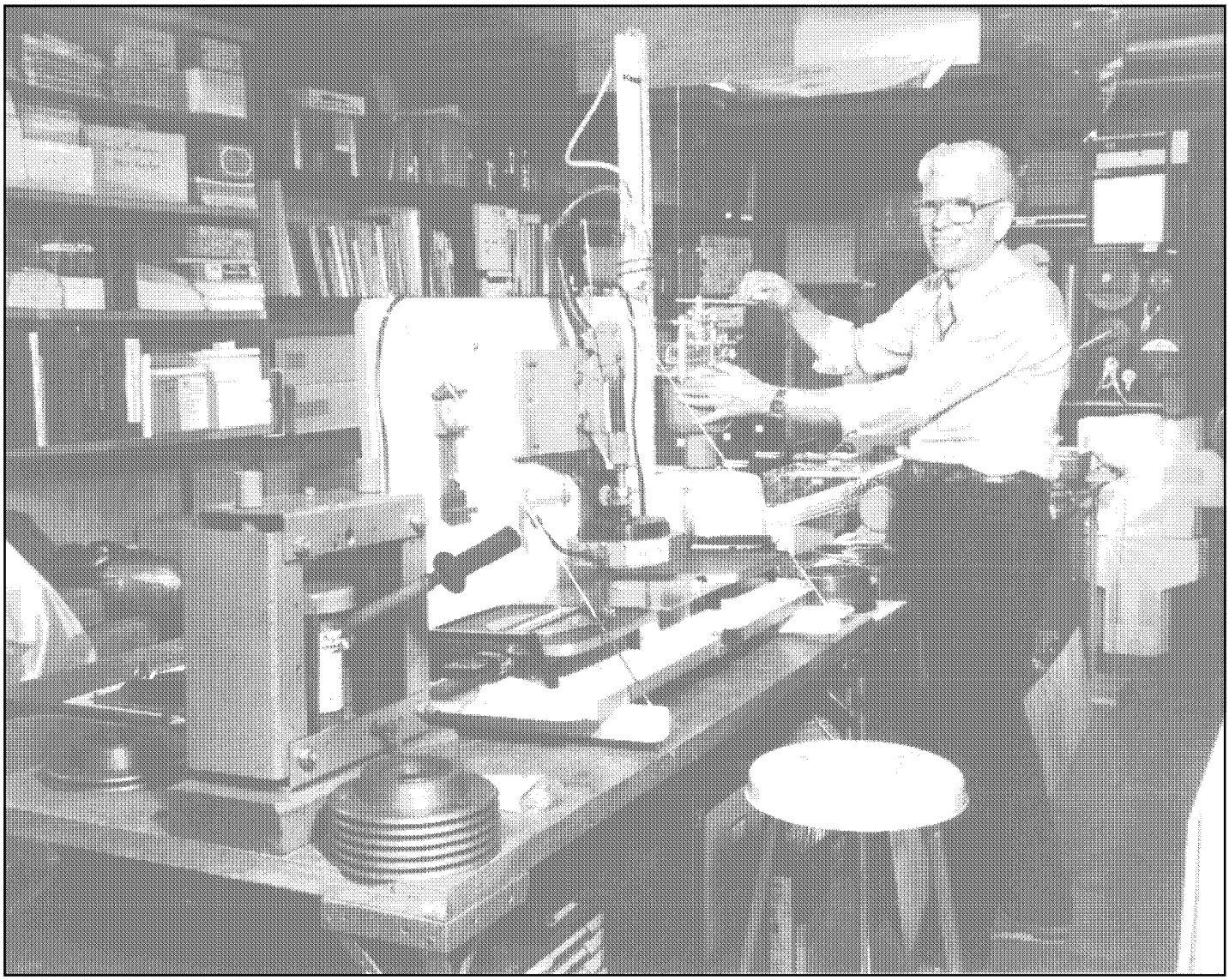
Author: Richard Perez, c/o Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

*Please let us at Home Power know what your RE business is doing. If we can help out, we will. Richard*

Special thanks go to Alan Sindelar who stayed sober enough to actually transcribe the BS session that generated this article. Thanks also to Charlie Cowden, Chas Pinchney, and Kirk Herander who contributed ideas to this article. The following books can save you from making many mistakes:

Small Time Operator by Don Lancaster.

So, You Want to Start a Business and Why Small Businesses Fail by William Delaney



# Solar Pathfinder

## *an RE business success story*

Richard Perez

Every so often a tool comes along that is so functional, so simple to use, and so effective that everyone immediately realizes its value. The Solar Pathfinder is such a tool. The Solar Pathfinder accurately estimates the amount of solar radiation a site will receive. It is *the* instrument for locating PV arrays, solar homes, & solar heaters.

Above: Bernie Haines making Solar Pathfinders in his basement.
Photo by Bernie Haines and the self-timer

**The Solar Pathfinder's Inventor**

Bernie Haines, the inventor of the Solar Pathfinder, makes the instruments in his basement in Glenwood Springs, Colorado. Bernie was educated as a chemical engineer and eventually worked in manufacturing. Bernie is a long-time solar energy enthusiast and invented the Solar Pathfinder to fill the need for an accurate instrument to estimate solar insolation at a specific site. Solar insolation is the amount of sunshine a site receives.

**So is the Pathfinder useful?**

Consider this past year's SEER '91 energy fair at Willits, CA. The sites for all the booths were in the park and under the trees. While this was infinitely better than broiling in the parking lot like we did at SEER '90, it sure put a cramp in all the solar powered displays. Everyone wanted to borrow the Pathfinder to locate that one specific

place in their area that got the most sun. Consider that the Oregon Dept. of Energy requires a sun chart, like the one made by the Pathfinder, before paying Oregon RE tax credits. Consider that I did five Pathfinder sun charts before deciding on the location of our new PV tracker. Bottom line is that the first step of siting and estimating any solar-powered system (including thermal systems) is a Solar Pathfinder evaluation.

**Making the Pathfinder**

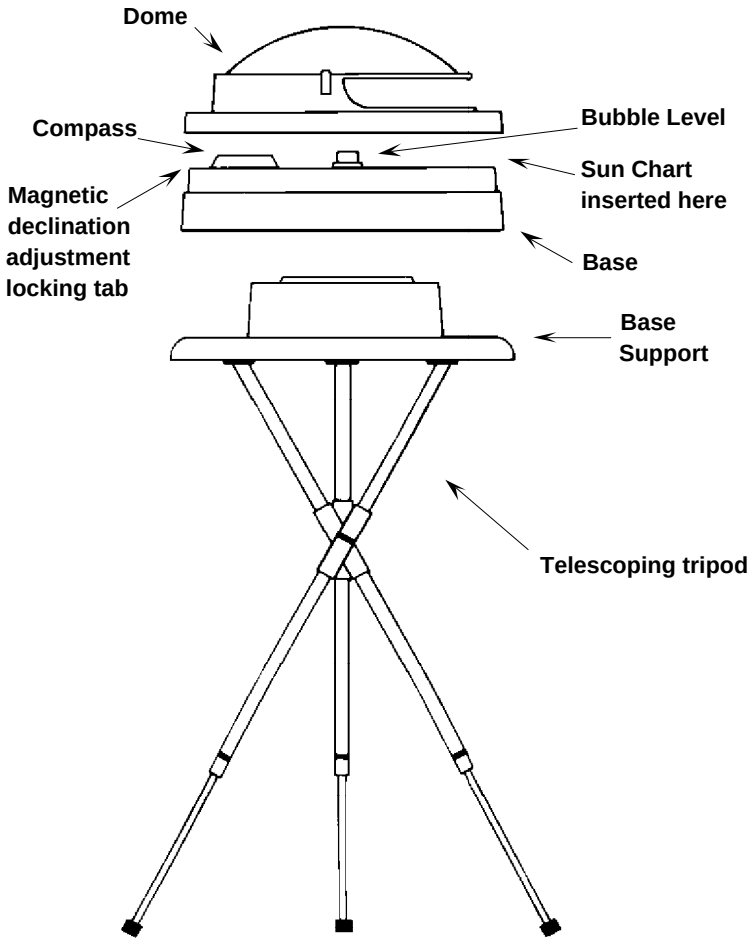
The pathfinder is a precision instrument made with custom tools created by Bernie specifically for the job. The main plastic housings are the only major part jobbed out to a subcontractor. All the rest of the parts are fabricated in Bernie's basement. Bernie has created an amazing machine from off-the-shelf items. Consider the complex and critical operation of bending a plexiglass sheet to the precise dome shape required by the Pathfinder. Bernie heats the plastic on temperature controlled griddles, then sucks the heated plastic into a mold using vacuum. Bernie built a vacuum forming machine just to make these domes. After the dome is formed and trimmed, it is placed on an ingenious rotating platform to check the dome's runout. The reflection of a light on the ceiling circles around on the dome as it spins on the rotating platform. In this manner, only perfect domes are selected for assembly into finished Pathfinders.

Bernie's manufacturing techniques are a symphony of basic physics applied with hardware store materials. What is even more amazing is the level of precision present in the finished Pathfinders–there's nothing funky coming out of Bernie's basement.

**A business looking for a home**

Bernie is now 69 years old and looking forward to retirement. Bernie has made and sold over 3,800 Pathfinders since he invented it in 1979. He would like to sell his successful Solar Pathfinder business to someone who will carry on what has been his life's work. The Pathfinder has become large enough that it has outgrown Bernie's basement and needs not only more space, but also more people to handle the business. Contact Bernie at 303-945-6503 if you want more info on buying the Solar Pathfinder manufacturing business, including all of Bernie's custom-made tools.

*the Solar Pathfinder*
*Designed and Manufactured*
*by Bernie Haines*




**Weight: 2 pounds without case. Diameter: 7.5 inches. Height: 34 inches.**

**RE Business**

Bernie and his Pathfinder are realizations of the business potential offered by renewable energy. Bernie saw a clear need and invented a product to fill that need. He then proceeded to manufacture the product himself. If this isn't home power, then I don't know what is.

**Access**

Author: Richard Perez, c/o Home Power, POB 130 Hornbrook, CA 96044 • 916-475-3179.

Maker: Bernie Haines, Solar Pathways, 31 Chaparral Circle, Glenwood Springs, CO 81601 • 303-945-6503.

# Build an Ampere-Hour Meter

Hollister McNeal



On any alternative energy installation, knowing the amount of energy produced or consumed is very useful. When storage batteries are used, Amp-hour meters on the input and output provide information on the energy production or consumption (since Amp-hours x battery voltage = energy in watt-hours). Although such Amp-hour meters can be purchased commercially, I chose to build one.

**Block Diagram**

A block diagram of the Amp-hour meter is shown in Figure 1. The SHUNT is used to measure the current. It must be inserted in the negative leg of the battery input or battery output. A shunt is actually a very low resistance precision resistor that produces a voltage across it proportional to the current flowing through it. The voltage that develops across the shunt is then amplified by 100 in the AMPLIFIER section. The output of the AMPLIFIER is then summed (integrated) in the ADDER section. When the ADDER output reaches a certain voltage level, the comparator changes its output state. This causes two things to happen: The LCD COUNTER is incremented by 1 and the ADDER is reset. The 5-digit LCD counter actually indicates hundredths of Amp-hours. Therefore the maximum count is 999.99 Amp-hours. The POWER CONVERTER section is needed to provide the appropriate regulated voltages to the electronics. It receives power from the 12 Volt battery bank and has +5, -5, and 1.5 Volt outputs. One power converter can easily support two separate amp-hour meters with a current draw of approximately 0.01 Amp.

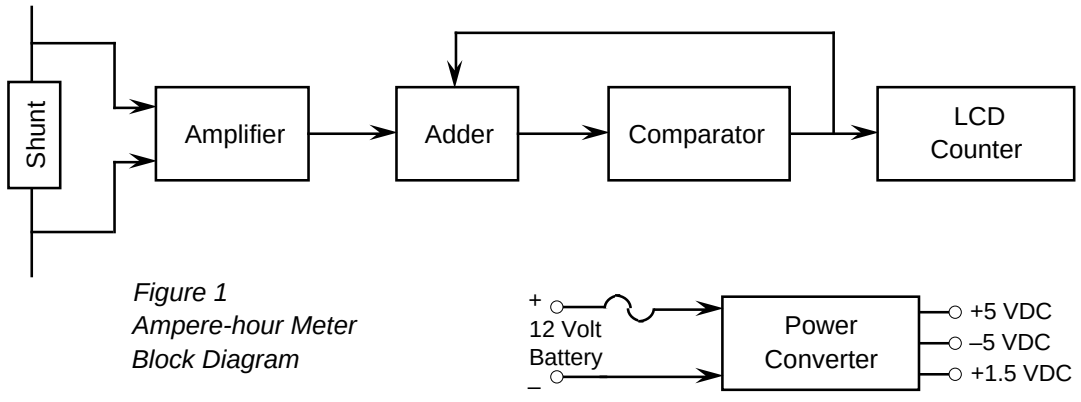
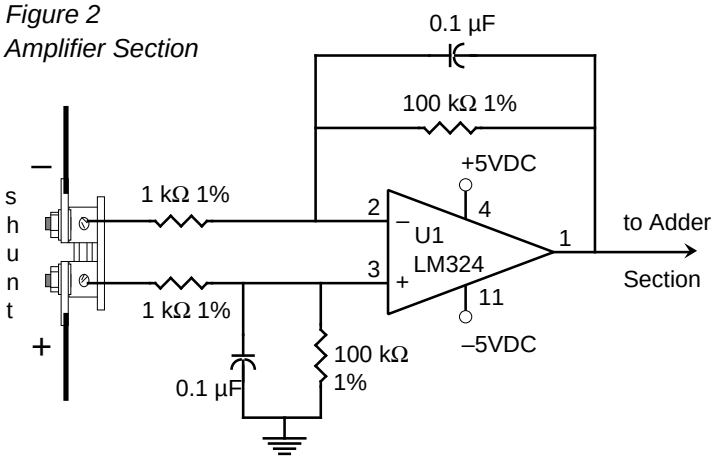



*Figure 1*
*Ampere-hour Meter Block Diagram*

**Amplifier Section**

Figure 2 shows the AMPLIFIER section in detail. It uses an LM324 op-amp configured as a differential amplifier with a voltage gain of 100. The resistors should be 1% tolerance for best accuracy. As there are 4 separate op-amps in a single LM324 package, the other 3 op-amps are available for the ADDER section or a 2nd Amp-hour meter.

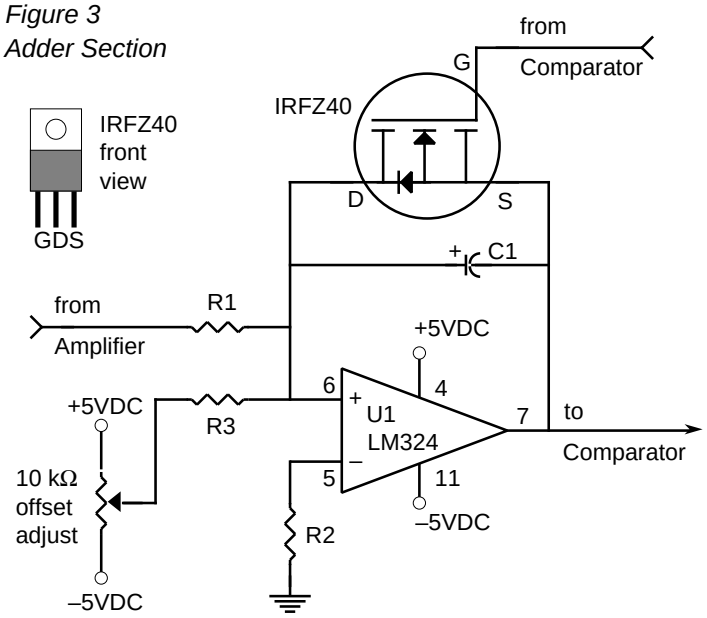
*Figure 2*
*Amplifier Section*




**Adder Section**

Figure 3 shows the ADDER section in detail. It uses an LM324 op-amp configured as an integrator. The adder is actually a subtracter, as its output goes from 0 to -2.5 Volts as it accumulates the current input. Note that the resistors R1, R2, R3, and capacitor C1 do not have

*Figure 3*
*Adder Section*




values specified. R1 and C1 are selected to obtain the correct counting rate. Their values are also dependent on the resistance of the shunt (Rs). The values can be approximately determined from the equation R1 = 1.44/(Rs x C1), with R1 in kiloOhms, C1 in µF (microFarads), and Rs in Ohms (Ω). I would recommend choosing C1 from available values, then calculating R1. R1 should be between 1k and 200k Ohms.

For example, my input shunt is 0.001 Ohm. I chose a 15 µF capacitor. R1 is then calculated to be 1.44/(.001 x 15) = 96 kiloOhms. My output shunt is 0.0001 Ohm. I chose a 4.7 µF capacitor. R1 is then calculated to be 1.44/(.0001 x 4.7) = 31 kiloOhms. To compensate for component tolerances, I would recommend using a potentiometer for R1 and adjusting it after the circuit is built for proper calibration (see CALIBRATION). Also, R2 should be chosen approximately equal to R1 (within 10%). Capacitor C1 should be tantalum for best accuracy. Make sure the capacitor is installed to match the indicated polarity.

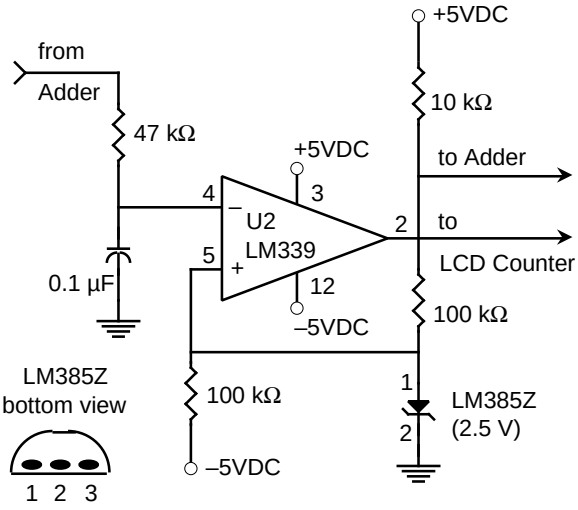
Resistor R3 is selected to optimize offset adjustment using the 100k Ohm potentiometer. Offset adjustment is necessary to assure that the Amp-hour meter is accurate for low or zero input currents. If R3 is too low a value, it is very difficult to set the pot to the optimum value, since a slight change in the pot will cause a large output variation. If R3 is too high a value, no pot setting will compensate for the offset. I used two 10 megaOhm resistors in parallel (5 megaOhm effective) on my two meters.

I used an IRFZ40 MOSFET to rest the adder by shorting out the capacitor C1. Other MOSFETs such as the IRF511 (Radio Shack #276-2072) will probably also work. Note that the MOSFET has an integral diode to keep the tantalum capacitor from going more than a few tenths volt reverse polarity.

**Comparator Section**

Figure 4 shows the COMPARATOR section in detail. It uses an LM339 comparator. As there are 4 comparators in a single LM339 package, the other 3 comparators are available for a 2nd Amp-hour meter or other circuitry (I used 2 comparators to implement a high battery voltage/low battery voltage detection circuit). The zener diode in the schematic is a precision reference diode LM385Z. When the adder output reaches -2.5 Volts, the comparator output will rise to approximately 3.7 Volts, which will both increment the counter and reset the adder. The comparator output will remain high until the adder output approaches 0 Volts. The comparator output will then go back to approximately -5 Volts.

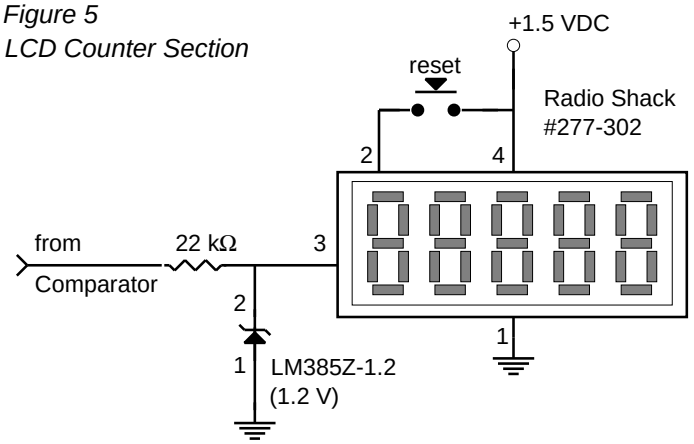
*Figure 4*
*Comparator Section*




**LCD Counter Section**

Figure 5 shows the LCD COUNTER section in detail. The LCD counter is Radio Shack #277-302. As 1.5 Volts is generated by the power converter circuitry, no 1.5V AA battery is needed. The zener diode in the schematic is a precision reference diode LM385Z-1.2. It is used along with the 22 kΩ resistor to provide the correct logic level to the counter. The reset switch is used to reset the counter display to 00000. The display will read up to 999.99 Amp-hours. There is no decimal point in the display. Perhaps one could be "taped" onto the display if desired.

*Figure 5*
*LCD Counter Section*




**Power Converter Section**
Figure 6 shows the POWER CONVERTER circuitry in detail. I used a 1/2 Amp fuse although a smaller fuse (1/4 Amp) should also work fine. The fuse was placed in a Radio Shack #270-1211 inline fuse holder. An On-Off switch after the fuse could be added also. Four op-amps are used, with 3 being in one LM324 package (U3) and the 4th in another LM324 package (U4). Do not attempt to combine these op-amps any other way as their power pins are hooked-up differently (U3 uses +12 and GND, U4 uses +5 and -8). Be careful to observe the polarities on the 10 µF and 47 µF capacitors. The +5 and -5 voltages are not exact and will vary with the tolerances of the resistors used. The -8 voltage is not regulated and varies with the 12 Volt battery voltage and with the current draw on the -5 voltage output. Pin 8 of U3 oscillates at approximately 1300 Hertz.

**Construction**
I placed the electronic circuitry for two Amp-hour meters on a single Radio Shack #276-162 printed circuit board mounted inside a Radio Shack #270-232 box. The circuit board was quite crowded. I would recommend using either two of them or else using a larger board. I mounted the switches and LCD counters on the surface of the box. Terminals mounted on the surface of the box were used to wire the shunt inputs and battery inputs. The inline fuse was placed close to the batteries. I drilled holes for access to the pots mounted on the printed circuit board inside. I also brought out the adder output terminals for ease in offset adjustment.

**Calibration**
The offset potentiometers are best adjusted with zero current in the shunt. Adjust the pot until the output of the ADDER section is a stable (unchanging) negative voltage between 0 and -2.5 Volts. Particularly with the 0.0001 Ohm shunt this is difficult to do. Use a digital voltmeter if possible. A rate of change of 0.01 Volt per second will give a total error of 3.6 Ampere-hours per day.

The counting rate is adjusted by changing R1 in the ADDER section. The shunt should now be drawing a steady current (preferably on the high side, such as with the solar panels in full sun for an input shunt, or a water pump or other heavy load for an output shunt). Measure the voltage across the shunt with an accurate digital voltmeter and divide by the shunt resistance to determine the current. Use a watch or preferably a stop-watch to time a set number of counts on the LCD counter (the more counts the more accurate the result). The number of seconds should then be SECONDS = COUNTS X 36/CURRENT. For example, with a current input of 10 Amps, 10 counts should take 36 seconds. For a current output of 50 Amps, 100 counts should take 72 seconds.

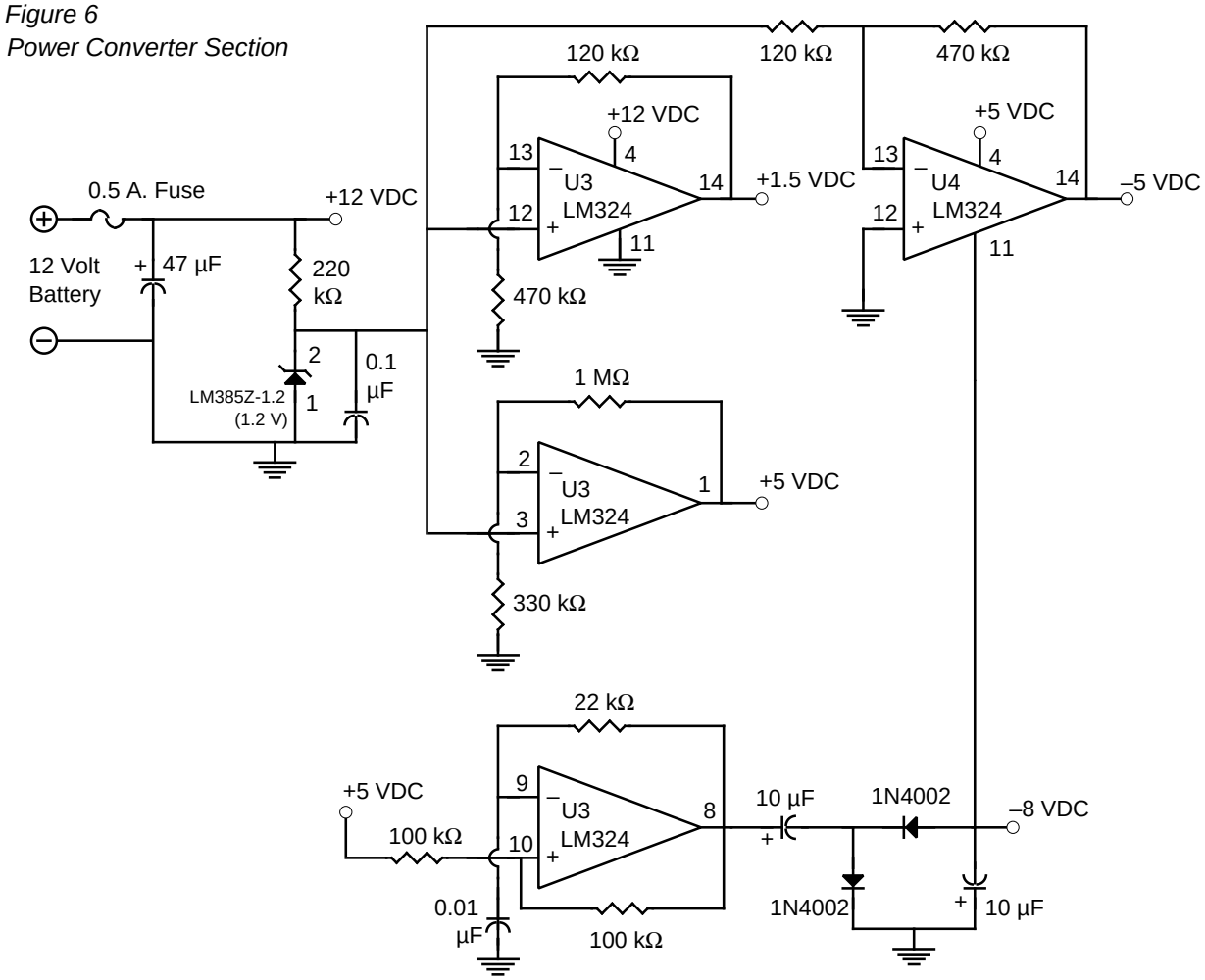
**Operation**
In my setup in Northwestern Pennsylvania, one Amp-hour meter monitors battery input from six Solarex MSX-60 solar panels. The other monitors the battery output going to a Trace 2012 inverter. Each day before sunrise both meter readings are recorded and then the meters are reset to 00000. The meters have been in operation for about eight weeks. So far I have been averaging about 100 Amp-hours per day for both battery input and battery output. I expect these mid-summer readings will drop considerably by late fall and winter.

**Limitations**
If the voltage drop across the shunt is more than 0.03 Volts (corresponding to 30 Amps on an 0.001 Ohm shunt or 300 Amps on a 0.0001 Ohm shunt) the 100X amplifier may saturate. This will not damage anything but it will cause the Amp-hour meter not to record at more than the amp rate corresponding to 0.03 volts. Reducing the gain from 100x will solve the problem. Replace both 110 kOhm resistors with the same smaller value. However, R1 and R2 or C1 in the ADDER section will also need to be proportionately reduced.

The LCD counter has a maximum counting frequency of 7 counts per second which corresponds to approximately 250 amps. Again, no damage will occur if this frequency is exceeded but the counter may not increment correctly. The solution would be to have the counter increment for tenths of amp-hours instead of hundredths of amp-hours. The easiest way to do this would be to replace both the 100 kΩ resistors in the amplifier section with 10 kΩ resistors, thereby making a 10X amplifier.

It is not possible for this Amp-hour meter to count

*Figure 6*
*Power Converter Section*




backwards. Therefore the shunts should be placed so that the current flow is always in one direction. The shunts have to be installed in the negative leg of the battery.

As the temperature of the circuitry changes the offset adjustment will change. I would recommend setting the offset at least once a month, preferably at a temperature that is "normal" for that month. The circuitry should be indoors and not exposed to excessive heat, cold, or humidity. Probably the best improvement in this Amp-hour meter would be to use op-amps for the AMPLIFIER and ADDER that have a lower offset voltage and less drift with temperature. The OP177 op-amp is much better than the LM324, although it is not at all pin for pin compatible.

**Access**

Designer: Hollister McNeal, 714 Pleasant Dr., Warren, PA 16365

LM385Z, LM385Z-1.2, IRFZ40, & most other parts: Digi-Key Corp., 701 Brooks Ave. S., POB 677, Thief River Falls, MN 56701-0677, 800-344-4539.

LM385Z, LM385-1.2, & most other parts: Jameco Electronic Components, 1355 Shoreway Rd., Belmont, CA 94002, 415-592-8097 ($30 Minimum order).

LCD Counter &, most other parts: Radio Shack.

Shunts: Deltech, 13065-H Tom White Way, Norwalk, CA 90650, 310-926-2304.

HOME POWER #24, Page 45: information on making shunts.

# From City to Country

Therese E. Peffer



I had always lived in the city. Turn on the faucet, water rushes out. Flick a switch, light floods the room. Rotate a dial and the room gets warmer. Flush. Almost magical. As long as the bills are paid, nothing requires you to think about the source of water or electricity, how much is used, or even where the waste goes.

**Enter Home Power**

The last three months have been different. I moved from Berkeley, CA to Agate Flat, OR to work for Home Power Magazine. Living in the country requires one to be concerned with where the water, light, and heat come from and where the waste goes. Don't get me wrong–I often wondered where my city water and energy came from, but now I am closer to the sources and the sinks. We must be actively involved with the resources we use; conservation comes naturally (less work for us!).

I came to learn about renewable energy. Again, not that one cannot learn in a more urban setting, but I am immersed in the application here. Opening the daily mail with its comments and questions from readers is an education in itself. I am a novice–less than a year ago, I didn't even know what "PV" (photovoltaic) meant. I struggle through the technical articles herein, but I'm learning. Discussion of watts, voltage, amperes, and basic battery chemistry awakens memory of physics and chemistry courses, but it makes more sense now in a real life situation. I started keeping a list of the new vocabulary–nicad, inverter, charge controller, regulator –and the pieces are beginning to fit together.

Of course, many more questions arise (how else to learn but to ask questions?). I'm beginning to appreciate the complexity rather than be overwhelmed by it. What helps is imagining how I would set up my own system, or something for my parents' travel trailer. From site selection to defining needs, from what kind, how many, to ac vs DC, and then the study of cost-effectiveness, the process of developing an RE system has many facets!

**The Question**

Everyone has their own particular interest in the renewable energy field, whether batteries, solar cooking, or environmental concerns. I am interested in education.

How do people become aware of the so-called alternatives to the ubiquitous utility? Where do those interested learn about photovoltaics, solar thermal, hydrogen, water, and wind power? What sparks the interest–personal freedom, ecology?

What got me hooked was reading about appropriate technology projects in developing countries. It is the philosophy of using local resources in a way that respects local culture and environment in small-scale projects that attracts me.

Lack of excess spawns creativity. When people don't have a lot of resources, they make do on what they have, using mud, bamboo, string–whatever comes to hand. Living from the land implies a conservation of resources and simplifying of needs (we use water that's nearby, and because of the drought, as little as we can). When you rely on the natural environment for your livelihood, you feel close to it. People have been living sustainably (taking what they need from what the land can give) and with little impact on natural cycles for thousands of years.

**Appropriate to U.S.?**

In the United States, things are not so simple. We import oil thousands of miles to light and heat our homes. We cut trees for export. We ship water and electricity for hundreds of miles down canals and wires. Hours are spent on the road commuting to work. We flush nutrients out to sea.

Technology offers benefits, certainly, but large-scale application can invite separation from the land, excess, and waste. Presently, most Americans live in urban areas, and do not know where their water and electricity come from, and where their waste goes. There is no initiative to conserve water or energy–just "pay a little extra."

**Changing Scene**

There is hope. In these pages, I read about people recycling motorcycle parts into wind machines, making trailer heaters out of car parts, and creating energy from manure! With renewable energy, people can move to the country and enjoy the comforts of the city. Besides living

amongst the beauty, there is security, freedom from utilities, and less pollution.

For urban areas, I have seen programs to take the magic out and put reality in. Such projects introduce open space, reintroduce native environments, encourage pedestrian traffic, or integrate agriculture into a city. The Sustainable Cities conference held in Berkeley encouraged urban sustainability: increased awareness of resource use in a more efficient city design. There are a growing number of utilities that encourage conservation through weather sealing, energy efficient appliances, and compact fluorescent lights.

The Integral Urban House, a renovated Berkeley Victorian, demonstrated self-reliant living in the city to the public, until its closure in 1985. The house featured passive solar design, a composting toilet, solar heated water, and grey water system. A large vegetable garden, rabbits, bees and fish were raised in the back yard. So, one can feel in touch with nature and be aware of natural resources in the city.

**Education at any age**

How to get others hooked? The first step is education–creating awareness of energy and environment, energy and politics, and alternatives to what we do now. Through education, we can refine the questions and make better choices.

For inspiration, we have a fourth and sixth grade class from Penasco Elementary School in Penasco, New Mexico. Recently, they wrote to Home Power requesting a subscription in return for writing about what they are learning about solar power. We are delighted with their suggestion of a Kid's Corner in Home Power, and introduce the first with this issue (pg. 50). We salute Brad Rose of Solar Works for dedicating his Friday afternoons to teaching these youth.

**End Note**

Back in Berkeley, I tried to learn more about sustainable forms of energy and came up with few sources. It's great to finally be immersed in it! But, I am interested in where opportunities for learning about RE are across the nation. We are aware of some schools out there, but there must be more! Please drop me a postcard if you know of a class at your local school, university, college, or trade school in RE, and we can spread the word!

**Access**

Author: Therese Peffer, c/o Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179

SCI ad
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4.5 Horizontal by 4.9 Vertical

# Kids Corner

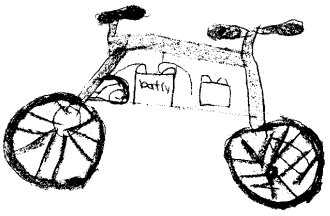
Tara Wade, 4th grade

Dear Home Power Magazine,

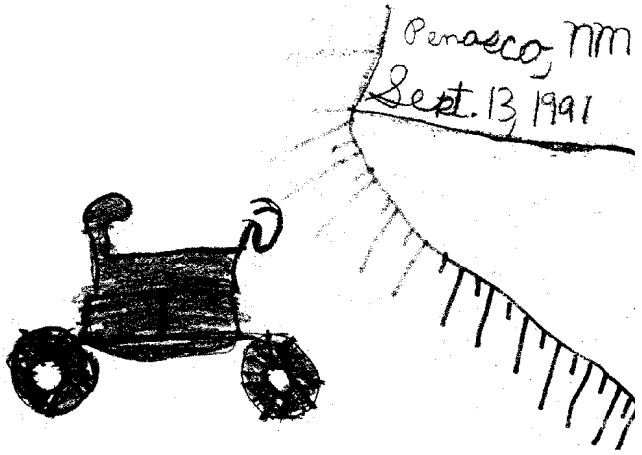
Hellow, My name is Yolanda Two Bears. I am twelve years old. I go to 6th grade At Penasco Elem. Every friday Brad Rose comes to our class. He works with Solar Works. He teaches us about Solar Power. We enjoy him. Could we have a free Subcribtion to "Home Powers?" I think the Magazine should have a Kids Korner. In return my class will write articles and send them to you.

We are learning how to make Solar Ovens, Solar cars, Solar mini ~~bikes~~ Bikes and we are going to have an Solar fan in our classroom. Thank You

Sincerly,
Yolanda Two Bears.



Frank Pacheco, 4th grade




Corine Gibbard, 4th grade

Hey Kids!
This page is for you. Send us your pictures and stories about solar power, and we'll print as many as we can.

Therese Peffer
Home Power

Dear Home Power:

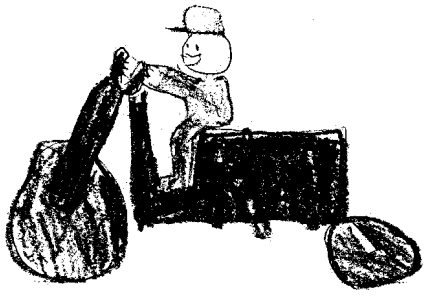
We would like a free Subscription to "Home power." Every Friday a person from Solar works comes to talk about Solar. His name is Brad Rose. We are building a small solar car and maybe a solar oven. The Free Subscription is For the Class. IF you Send us a Subscription we'll write articles.

Sincerely,
John Rohan

Dear Sir:

Our fourth grade class is learning about solar energy from Brad Rose. So far we have learned about an electric minibike, solar panels, and how solar panels make electricity. We are wondering if you could send us us a free subsciption of your magazine. if my class keeps sending you letters about what we do every Friday.

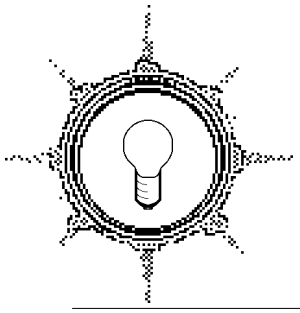
Sincerely,
Jason X. Romero



Peter Lopez, 4th grade

Solar at any age: Home Power welcomes the inspiration of Kid's Corner, by Grade 6 (Mrs. Rose Compton) and Grade 4 (Mrs. Sue Thielke), Penasco Elementary School, Penasco, New Mexico.

Subscription Form



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**I NOW use alternative energy (check one that best applies to your situation).**

☐ **As my only power source** ☐ **As my primary power source**

☐ **As my backup power source** ☐ **As a recreational power source (RVs)**

**I want to use alternative energy in the FUTURE (check one that best applies).**

☐ **As my only power source** ☐ **As my primary power source**

☐ **As my backup power source** ☐ **As a recreational power source (RVs)**

**My site has the following alternative energy potentials (check all that apply).**

☐ **Photovoltaic power** ☐ **Water power**

☐ **Wind Power** ☐ **Other**

HP#26

**I now use OR plan to use the following alternative energy equipment (check all that apply).**

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|---|---|---|---|---|---|
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| ☐ | ☐ | **Wind generator** | ☐ | ☐ | **Batteries** |
| ☐ | ☐ | **Water power generator** | ☐ | ☐ | **Inverter** |
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# A Simple RV Hydronic Heating System

Jim Phypers



Conventional forced-air heating systems have fixed heat output and are either on or off. Hot water heating offers gentle, continuous heat and adjustable heat output. A simple hydronic system using a hot water circulating pump, large fan, and automotive type heater core transformed a poorly heated 24 foot travel trailer into a comfortable, evenly heated home. The system was a big improvement in efficiency, economy, quietness, and comfort over the propane forced-air furnace it replaced. The project served as a valuable learning experience and prototype for larger applications.

**The Challenge**

Whatever happened to good, old-fashioned hot water heating systems? I used to love to visit my grandmother in Ohio because her house with its hot water circulating pipes in the floors was the warmest and coziest place in town. I decided to try and install a hydronic heating system in my not so warm 24 foot travel trailer home. I could scarcely find any books or articles on the subject or anyone who knew much about it. My truck's heating system is hydronic and works very well. Why not use this as my model? The result was a system which keeps my trailer as warm and cozy as Granny's house. The system is at least 50% more efficient and economical than conventional heating systems. This hydronic system amazed my skeptical friends and the local RV repairman who were all quite convinced such a "primitive" system could not possibly work.

**The Plan**

The concept of my hydronic heating system is simple. Establish a closed loop in my existing hot water system: a standard RV propane water heater with a six gallon tank. Circulate the hot water through a standard automotive heater core. Blow the heat from the core out into the room by placing a fan behind the core. Enclose the fan and core in a box to minimize heat loss and direct all air from the fan through the core. Locate a high efficiency fan and circulating pump to minimize Amperes consumed in my modest 12 Volt, two PV panel electrical system.

**Material Used**

While the fan, pump, and heater core were purchased new, somewhat less efficient and/or used items could have been obtained at less expense, or recycled items used. The Hartell pump has three advantages over other pumps on the market: (1) high efficiency with very low 0.7 Amp draw, (2) remarkably quiet operation (unlike many other circulating pumps), and (3) no radio interference due to its brushless design.

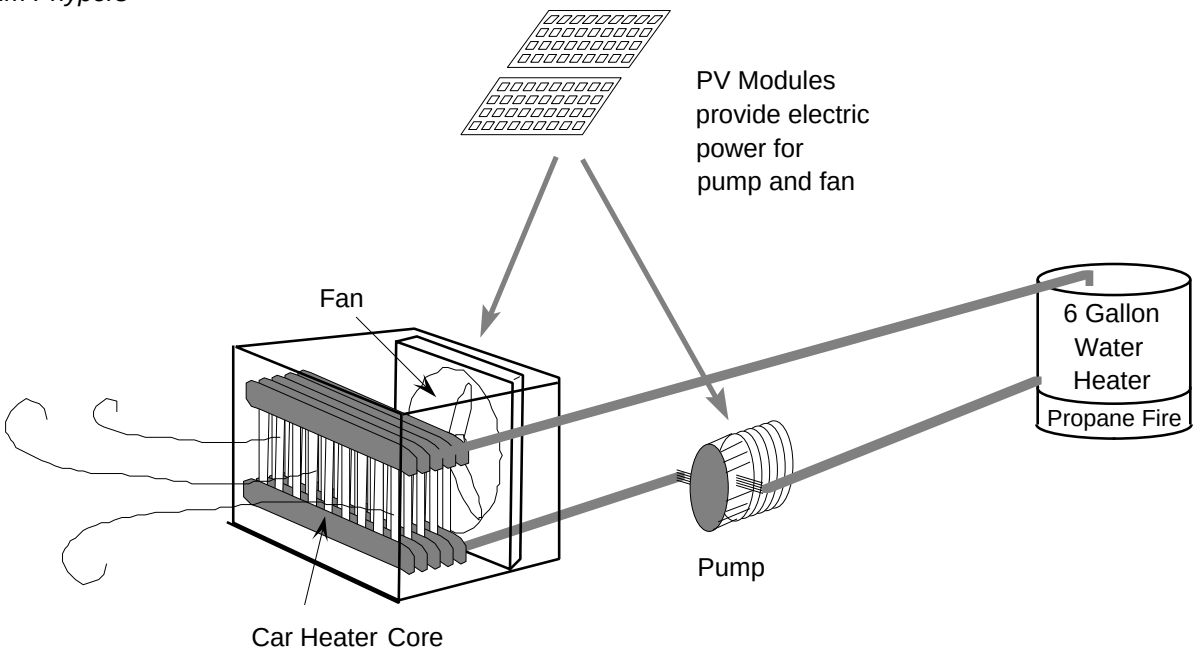
The fan used in this system is also remarkably efficient and quiet. This is due to the fact that it utilizes a Clifton industrial motor which is a 24 Volt unit running at 12 Volts and therefore half speed at only 750 rpm. The fan has large, very lightweight 16 inch aluminum blades. This fan moves an amazing 1,000 cubic feet per minute (CFM) of air using only 1.1 Amps. A standard RV fan draws about 1.4 Amps and moves only 350 CFM.

**Putting It Together**

Initially, I used a small RV fan placed behind the heater core and did not enclose them in a box. This arrangement was sufficient to heat the trailer, but high water temperature was required as well as running the fan at full speed. Utilizing a larger fan, and enclosing the fan and core in a box dramatically increased efficiency. Much lower water temperature and fan speeds were needed. A small door was cut in one side of the box so that the

| Material Used | Cost | % |
|---|---|---|
| Hartell brushless DC Pump (1.7 A @12 V) | $155 | 43.7% |
| 16" Dayton/Clifton fan (1.1 A @ 12 V) | $105 | 29.6% |
| Automotive heater core (6.5" X 10") | $53 | 14.9% |
| 12 Volt fan speed control (rheostat) | $25 | 7.0% |
| 25 ft. heavy duty auto heater hose (0.75") | $15 | 4.2% |
| 6 standard hose clamps | $2 | 0.6% |
| Cardboard box | $0 | 0.0% |
| Total Cost | $355 | |

*Hydronic RV Heating System*
*by Jim Phypers*




position of the heater core could be adjusted and hose clamps tightened. A large air intake hole was cut in the rear of the box. I found it very important to cut the hole for the heater core exactly to size to avoid air leakage and loss of efficiency.

I tried connecting the pump on either side of the heater core in the closed loop. Both positions seemed to work equally well to circulate the water through the core. However, since my water system is not pressurized or connected to any external system, the water storage tank does not fill to the top where the hot water outlet is located. With the pump sucking air instead of hot water, the system didn't work at all. I turned the pump around and reversed the direction of flow in the loop. With the pump now pulling hot water from the bottom of the tank and returning the cooler/used water to the top of the tank, I was in business.

To complete the system, a 12 Volt dimmer control ("conserve switch") was wired to the fan. Being able to adjust the speed of the fan precisely is more than just a luxury since it enables you to control the exact amount of heat convected into the room. The conserve switch is a sophisticated, solid-state device rather than just a few resistors which dissipate and waste the energy not used by the fan as heat. With the fan running most of the time at half speed or less, the dimmer control saves better than half an Ampere per hour. This adds up to a significant savings over time, particularly in a small PV system.

**Big Advantages**

Noel and Barbara Kirby in their book "RVers Guide to Solar Battery Charging" observe that "the typical RV furnace is an abysmal creation that will use all your propane in a weekend and kill your battery overnight." They are dead right. That is just what happened before installing the new hydronic system.

I live in the Anza-Borrego Desert near Borrego Springs, California where winter temperatures rarely go below the mid-30s. The area has frequent high winds at night. Wind-chill temperatures can be very low and provide a good test of any heating system. Using high fan speed and water temperature, the new system passed the test with flying colors. There were a few memorable windy nights when I felt the trailer was making an unscheduled trip to Arizona, but I am happy to report that at least the journey was a warm one.

The hydronic system uses at least 50% less electricity and propane than the forced-air furnace. Both systems use propane as heat sources, but the burner in the furnace is larger and consumes about twice as much propane per hour. Both system use electric power, the hydronic for its pump and fan, the furnace for its fan.

I have found that the burners in each system operate roughly the same length of time, about 25 minutes per

hour during the evening with a 35 degree differential between inside and outside. This translates to 3600 BTUs per hour for the hot water system, 8200 BTUs per hour for the forced-air system. While the pump and fan run all the time in the hydronic system, they draw only 0.7 Amps and 0.8 Amps respectively–a total of only 1.5 Amp-hrs. The furnace's fan, which draws 6.5 Amps, runs only 25 minutes, drawing a total of 2.8 Amp-hrs. for the one hour test period.

*Hydronic Heating Advantages*

| | Hydronic Heating System | Forced-Air Heating System |
|---|---|---|
| **BTUs Required** | 8,800 BTU | 20,000 BTU |
| **Amps Used** | 1.2 to 1.8 Amps | 6.5 Amps |
| **Comfort** | Gentle, continuous heat | High heat level then nothing |
| **Heat Output** | Adjustable (water temp & fan) | Not adjustable |
| **Noise (Fan)** | Quiet | Loud |

**Two Complications**

No heating system relying on propane or natural gas is worth much if the main burners or pilot flame goes out at unexpected and unfortunate moments. I have found propane water heaters to be a contrary lot (at least the RV variety). No amount of cleaning, replacing the thermocouple, etc. seems to cure the tendency for their pilots to blow out. The answer to cold awakenings in the middle of the night is a $30 investment in an electronic reigniter unit. Of course, if your water heater is a non-pilot model with an electronic ignition, you can skip this section. These reigniter units consume only 100 milliAmps at 12 VDC and only use power while they are emitting sparks to relight the pilot. They can be hardwired into your system and forgotten. A small 2 inch x 3 inch box mounts on the inside of the hot water heater compartment with a tiny element attached to the pilot burner. Unless you don't mind lighting pilots in the dead of night at 36°F, spend the $30.

If the thermostat in your water heater doesn't maintain the temperature of the water at a more or less constant level, then it will need to be replaced. Since my hot water thermostat as well as pilot lights have it in for me, my thermostat had to be replaced. The new thermostat does not take holidays and doesn't let the water get cold before deciding to turn back on. Now the hydronic system can function as it is should.

**Hydronic vs Catalytic Systems**

Some of my friends (critics) and the Kirby's themselves in their solar/RV book point out that propane catalytic heaters offer essentially the same advantages over a forced-air furnace as the hydronic system. In part, this is true. A catalytic heater is quiet in operation. It consumes less propane than a forced-air furnace, and its heat output is adjustable. The heat produced is gentle and continuous. It has one advantage over the hydronic system in that the unvented models require no fan and therefore no electricity–but see the warning which follows. Vented catalytic heaters (the "CAT" made in Washington State) use 1/2 Amp per hour for a small fan which is designed to remove some of the exhaust fumes (6,000 BTU model).

The big disadvantage of a catalytic heater is that combustion occurs within the space being heated. Oxygen is used up and exhaust gases produced. I have used both vented and unvented models in my trailer. By the time you have opened enough windows and/or cracked enough doors, so that there is sufficient oxygen being replaced and the exhaust fumes allowed to escape, you have lost a significant proportion of your heat. This is particularly true of unvented catalytic heaters which many people regard as dangerous and which some dealers will not carry. The results of too little oxygen or too much exhaust gas in the room are obvious. I grew tired of worrying about whether I had opened enough windows. After a couple of miscalculations and getting sick, I removed the heater. In a large room with high ceilings, these problems are probably minimal. But in the confines of a 24 foot travel trailer (about the square footage of a 12 ft. x 12 ft. bedroom), an unvented catalytic heater was an unsafe and unwise choice for staying warm.

The vented "CAT" heater has a vacuum-like device at the top of the catalytic burner pad which sucks fumes away as they rise from the glowing pad beneath. This results in less fumes escaping into the room, but it is hardly completely effective. Combustion still occurs in the room and uses up oxygen. The need for vigilance in maintaining proper ventilation still exists. I would not recommend even a vented catalytic heater for people with respiratory and/or sinus problems. The "CAT" heater didn't last long in my trailer before I removed it.

**Wider Applications**

A big plus for hydronic heating is that it works well with that wonderful non-polluting, renewable, non-fossil fuel, domestic, abundant, free energy source–our sun. No grisly, global complications are involved in using solar

energy...(further and increasingly impassioned pronouncements)...Amen. There are many chilly days in winter when heat is needed, and the sun could be heating water for the hydronic system in coils on the roof. Yes, the plans are on the drawing board.

An automotive type heater core is certainly only one of several possibilities for the heat exchanger unit. For the 140 square feet of space to be heated in my trailer, it worked perfectly. For larger spaces, the coils out of an old refrigerator would seem to be a good candidate. A little imagination and recycling should create any number of workable units.

Myson, Inc. of Gateshead, England make very attractive hydronic "Classic II Fan Convector" units which are coupled with their instantaneous-demand propane water heaters. The fan convector units vary in size from 5,000 to 24,000 BTUs. They have a three speed fan and a heat exchanger made of copper tubing and aluminum fins. For larger applications, they make gas fired boilers rated at 50,000 to 80,000 BTUs to be coupled with multiple fan convector units. The Brits know how to keep warm!

**Summing Up**

Life is so much more pleasant with hot water heating. No more shouting over the roar of a blower fan. No more feeling cold when the furnace shut off. Just the amount of heat you want when you want it–what luxury! Visitors, including a somewhat chagrined RV repairman, remark how much more comfortable and warm our trailer feels than it did before (and also how much fresher the air is than in the catalytic heater days). We are using less propane, saving money, and in a tiny way helping our planet by consuming less fossil fuel. The system is easy to install. And it is so much fun to needle our neighbors about their obsolete, old fashioned, forced-air furnaces.

**Access**

Author: Jim Phypers, POB 163, Borrego Springs, CA 92004.

# Water and Electricity Do Mix

John Wiles

The old saying that water and electricity don't mix is not at all true when water is pumped by PV power in a safely installed system that meets the requirements established by the National Electrical Code® (NEC®). Although Article 690 of the NEC does not deal specifically with water pumping systems, other articles in the code do.

**Grounding**

As with other equipment in the PV system (including 12-and 24-volt systems), Article 250-43(k) requires that all exposed, noncurrent-carrying metal parts of motor-operated pumps, including submersible pumps, be grounded. These metal parts must be connected to the other metal parts of the system such as the module frames and grounded at a common point. This indicates that three-conductor cables should be used for the pump circuits–positive, negative, and equipment grounding. In three-conductor cables, the bare conductor may be used only for equipment grounding (Article 339-1(a)), and may not be used to carry current.

If the PV-powered water-pumping system operates at open-circuit voltages higher than 50 volts, Article 690-41 requires that one of the current-carrying conductors be grounded. This is in addition to the equipment grounding conductor. On certain maximum-power trackers, current boosters or pump controllers, this may pose a problem when control devices such as relays and transistors are placed in the negative conductor which is normally the grounded conductor. Grounding the positive conductor is permissible under these circumstances and will pose no problems if it is directly connected through the controller. Current shunts placed in a grounded conductor act like wires themselves, but care must be taken that they are not bypassed by unintentional multiple grounding of this conductor. In any event, the grounded conductor must have white insulation or, in sizes greater than 6 AWG, be marked at each termination with a white marker (Article 200-6(b)).

**Conductor Ampacity and Overcurrent Devices**

Each conductor must have an ampacity or current-carrying capacity equal to or greater than 125% of the maximum current flowing through it. For the PV array conductors, this would be 125% of the parallel module short-circuit current (Article 690-8). If a max-power tracker, current booster, or pump controller is used, the manufacturer should be consulted to determine the maximum worst-case condition of steady-state output current. This may be many times greater than the PV array short-circuit current and the conductors to the pump must be sized appropriately. Article 310 in the NEC gives conductor ampacities for various conductor insulation types, installation locations, and temperatures.

Overcurrent protection in the form of fuses or circuit breakers must protect each circuit in the water pumping system. The current rating of these devices must be equal to or less than the ampacity of the conductors they are protecting (Articles 240 and 690-8).

For example, a typical direct-drive water pumping system might have four 60-Watt PV modules connected in parallel. These modules can deliver 12.5 amps of rated short-circuit current to a current booster/controller. Number 10 AWG cable might be used from the PV modules to the controller. A 20-amp fuse might be selected to protect these wires from overcurrent. At certain load conditions, the current booster could supply 55 amps at 4 volts to the motor. Number 6 AWG cable would be needed between the controller and the pump, and a 75 amp fuse or circuit breaker could be used to provide the overcurrent protection.

**Disconnects**

Since a disconnect device will be required between the PV array and the controller (Article 690-C) and possibly between the controller and the pump, it seems appropriate to use circuit breakers since they serve as both the disconnect switch and the overcurrent device. They are very robust, easier to use than switches and fuses, sometimes less expensive than appropriately rated switches, and usually provide more satisfactory performance than fuses and switches. Square D QO residential circuit breakers are listed and rated by Underwriters Laboratories (UL) for direct-current use up to 70 amps and 48 volts (12-and 24-volt PV systems). Heinemann and Airpax breakers are UL listed with higher

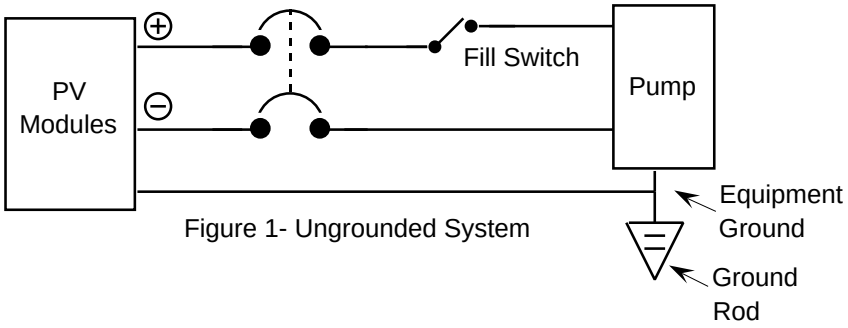



Figure 1- Ungrounded System

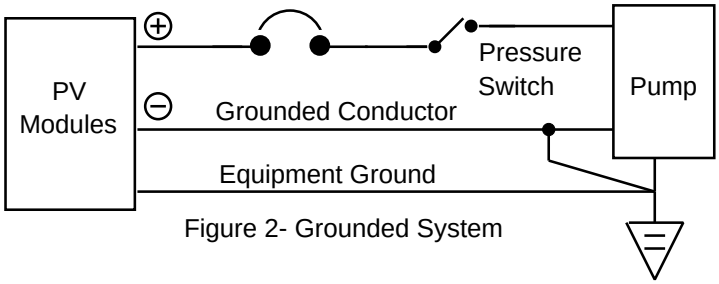



Figure 2- Grounded System

voltage and current ratings for the larger systems.

Pumps use electrical motors that are addressed by several sections of the code. Article 430 deals with motor circuits and controllers. Section H of this article requires a disconnect device for both the motor and the controller, and it is to be within sight of the controller and be readily accessible. This disconnect device can be either a switch or circuit breaker, but it must plainly indicate whether it is open (off) or closed (on). The branch-circuit overcurrent device such as a fused disconnect switch or circuit breaker may be used as the motor disconnect if it is rated and listed as a branch circuit protective device.

If a separate pump house is used, there are specific requirements for the disconnects which are based on the type of cable used between the power source and the pump house. If USE (Underground Service Entrance) cable is used, Articles 230-90 and 230-91 spell out the requirements. If UF (Underground Feeder) cable is used, then Article 339 tells how to install this cable.

**Example Diagrams**

There are several possible ways that a PV system might be connected to pump water. These examples are all direct-drive systems and have no batteries. The addition of batteries complicates the situation considerably and these issues have been addressed in previous Code Corner Columns.

Figure 1 shows a small system that uses only a fill or pressure switch and does not have a controller or power tracker. A disconnect switch is required between the PV array and the pump. Since one of the current carrying conductors is not grounded (OK if less than 50 volts open-circuit voltage), a two-pole disconnect switch must be used to simultaneously disconnect both the positive and negative conductors. If one of the current-carrying conductors is grounded, then only a single-pole switch is needed in the ungrounded conductor (Figure 2).

Figure 3 shows a grounded system with a current booster/controller. Disconnect/overcurrent devices are shown before and after the controller. They are shown ganged to completely disconnect the controller from the system, and they will more than likely have different current ratings.

**Summary**

Water and electricity can be mixed safely. Good judgment and compliance with the guidelines in the NEC can add up to a safe, PV-powered, stock-watering tank or a potable water system.

**Access**

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Heinemann Electric Company, P.O. Box 6800, Lawrenceville, NJ 08648, 609-882-4800.

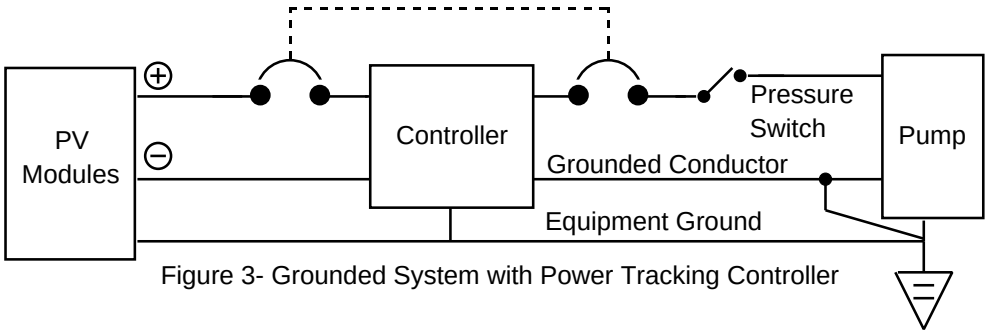


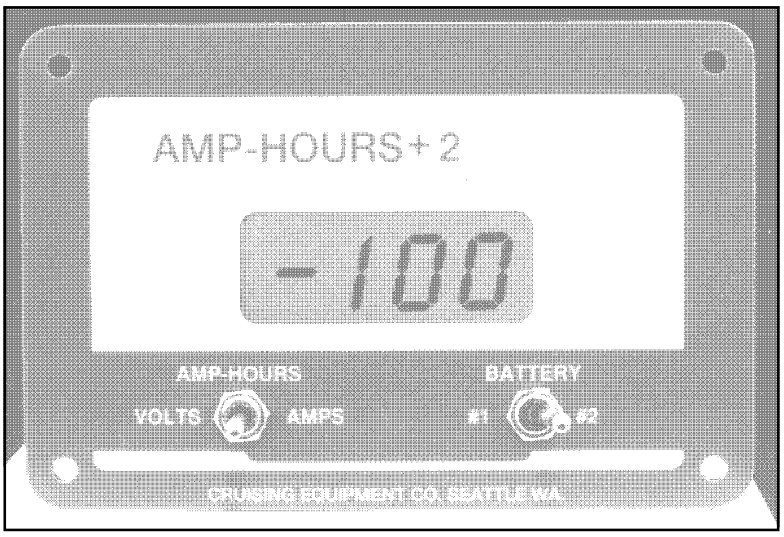

Figure 3- Grounded System with Power Tracking Controller

# Things that Work!

*Things that Work!*
tested by Home Power

# Cruising Equipment's Amp-Hour +2

tested by Richard Perez




Cruising Equipment introduced their first battery Ampere-hour meter two years ago. It rapidly became everyone's first choice for system instrumentation. Well, the fine fellows at Cruising haven't been idle. They have invented a new model Ampere-hour meter with radically better features, more intelligence, and it measures two systems at once!

**Battery Ampere-hour Meters**

A battery Ampere-hour meter keeps a net count on current flow into and out of the battery. It is a meter that tells us how much electric energy has been consumed from our battery. One chronic problem with all Ampere-hour meters is battery efficiency. No battery is 100% efficient. Some of the energy used to recharge the battery is lost as hydrogen and oxygen (via electrolysis) and some is lost to heat. A battery Ampere-hour meter must factor battery efficiency into its measurements.

The early model Cruising Equip. Ampere-hour meter used a control to set a specific battery efficiency. This meant that the user had to know the efficiency of his battery, and set it correctly on the Ampere-hour meter. Well, most of us don't know our battery's efficiency. Diddling the control through a hole in the meter's case turned out to be vague. What setting the early model Amp-hour meter amounted to was several months of dedicated trail and error. Both Steve Willey, of Backwoods Solar, and I fool around with electronics extensively. It took both of us months to accurately adjust the potentiometer on our early model Amp-hour meters.

After the meter was properly adjusted to the battery's efficiency, then all went well–until the battery aged and its efficiency changed. Then the whole adjustment rodeo went on again. The good news is that the new Cruising Equipment Ampere-hour meter is smart enough to learn the battery's efficiency for itself. It also updates this efficiency info regularly so the meter is aware of changes in the battery's efficiency.

**Shipping and Documentation**

The meter arrived in fine shape nestled in its plastic bubble wrap. The early docs were marked "draft copy not for public distribution" and were obviously not ready for prime time. Cruising Equip. is still working on producing the documentation for this Amp-Hour+2 meter.

The meter itself measures 4.5 inches wide, by 3 inches tall, by 1.75 inches deep, and comes with two shunts for current measurement. The unit is well encased in heavy plastic. Wiring access is via a multi-conductor cable poking out of the unit's back.

**The Amp-hour+2 Meter's Functions**

The Amp-hour+2 does more than measure bi-directional battery Ampere-hours. It is also a battery voltmeter and battery ammeter. The Amp-hour+2 can perform all of its measurements on two separate battery packs. Voltage

resolution is to 0.01 VDC, with a range of 8 to 16 VDC in 12 Volt models, and 16 to 32 VDC for 24 Volt models. Current resolution is 0.1 Amperes with a range of ±255.0 Amperes. Ampere-hour measurement resolution is 1 Ampere-hour with a range of ± 2000 Ampere-hours

The Amp-hour+2 uses an LCD (Liquid Crystal Display) with 0.4 inch tall numerals for information display. This display is well back lit by two green LEDs (Light Emitting Diodes) for night time viewing. There are two switches on the front panel. One selects the function of either net battery Ampere-hours, battery voltage, or battery amperage. The second switch selects the one of two separate battery packs.

This is a smart meter. This meter uses a microprocessor chip that talks to electronic memory (both RAM and ROM). The Amp-hour+2 has far more inside than a collection of op-amps. It has the intelligence to actually determine the efficiency of a battery and use this data to deliver far more accurate Ampere-hour measurement. Meter-determined battery pack efficiency is displayed for both battery pack channels. Remember the Amp-hour+2 does all its measurements (even efficiency) for one or two battery packs.

**Installing the Amp-hour+2**

I installed the meter in our system on Agate Flat. The first thing I noticed was a different shunt than the one used by the earlier model Amp-hour meter. The Amp-hour+2 uses a 500 Ampere, 50 milliVolt shunt with a resistance of 0.00001Ω. The previous meter used a 100 Ampere, 100 mV. shunt with 0.0001Ω resistance. The new Amp-hour+2 uses a shunt that has ten times less resistance than the previous model. The very low resistance of the new shunt is important because it is wired in series between the battery and all loads–like the inverter. Our inverter can consume over 400 Amperes when starting large 120 vac appliances.

I installed the Amp-hour+2 meter's shunt in series between the negative pole of the battery pack and all loads and power sources. The meter needs five wires to install it in the system. For a schematic of how this is done see the illustration on page 10 of this issue. Wiring the second battery into the meter is done with three additional wires which go to the second battery bank's positive pole, and the two terminals of the second shunt.

I could resist a peak inside the Amp-hour+2 meter. When the case came apart, I was confronted by two levels of densely populated printed circuit (PC) boards. A large surface-mount, microprocessor hangs out in a leadless chip carrier. Both PC boards are double sided and jammed with top quality electronic components. In terms of the level and amount of technology, Cruising Equipment customers are getting a good deal for their bucks.

**Programming the Amp-hour+2 Meter**

The meter needed to be told several bits of information about our system. The Amp-hour+2 needs to know our battery pack's capacity in Ampere-hours. It needs to know at what voltage and current we wish to consider the battery pack to be fully recharged. The Amp-hour+2 uses this information make more accurate measurements of the battery packs' state of charge. Programming is accomplished by inserting a tool into the side of the case and pushing a button.

**Accuracy of the Amp-hour+2**

I ran the Amp-hour+2 against two Fluke 87 Digital Multimeters. As far as I can tell after six weeks of testing, the Amp-hour+2 is at least as accurate as the Fluke 87s. The preliminary documentation I got with the meter contained no accuracy specifications. Bottom line is I couldn't catch the Amp-hour+2 making any errors in relation to the measurements made by the Flukes.

**Using the Amp-hour+2**

This meter provides a whole new level of information about our battery packs. I had always wondered what the efficiency of our old lead-acid batteries were. Well, according to the Amp-hour+2, our old L-16s have an efficiency of 71%. This is low and tells you why I am replacing all our lead-acid cells as fast as I can install recycled nicads. Measurement of battery efficiency is a breakthrough, and credit goes to the Cruising Equip. Crew for a job well done.

It is extremely handy to be able to measure battery voltage and net battery amperage using the same display. It much more functional to have all these high tech electronics monitoring more than one battery bank. There is a hell of a lot of information and intelligence in this small box. And there is a whole bunch of other features that I haven't even covered so far. For example, some optiona are high and low battery alarms, and a Pulse Width Modulator regulator.

**Cost**

The Amp-hour+2 is not cheap. The Amp-hour+2 model, which does two battery packs and comes with two shunts, lists for $399. A model called the Amp-hour+ has all the same functions as the two battery model, but only measures a single battery bank. The Amp-hour+ lists for $329 and comes with one 500 Ampere, 50 milliVolt shunt.

**Conclusion**

An Ampere-hour meter is the most useful instrument to have in a battery based system. Cruising Equipment's Amp-hour+2 meter is the smartest, most accurate, and most versatile Ampere-hour meter I have ever used. It is the only Ampere-hour meter to actually determine a battery pack's efficiency, use this data in its calculations, and display this data to the user. Cruising Equipment's new Amp-hour+2 meter is hot stuff.

**Access**

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Maker: Cruising Equipment Co., 6315 Seaview Ave. N.W., Seattle, WA 98107 • 206-782-8100.

# Things that Work!

*Things that Work!*
tested by Home Power

# Cygnet M-32 Battery Monitor

tested by Richard Perez

The M-32 is a twelve channel LCD voltmeter and ammeter. It measures DC voltage in six different locations and DC current in six different locations. One M-32 instrument package can monitor any combination of batteries, PV modules, hydros, wind turbines, inverters, and/or DC loads. Instead of many instruments, each with its own display, the M-52 can perform twelve different measurements in a single package.

**Shipping and Documentation**
The M-32 arrived via US Post Office in good shape. It was well-packaged in plastic bubble wrap, so I didn't have to spend most of the afternoon chasing styrofoam peanuts around the floor. The documentation is adequate for installation and operation of this instrument. The docs could be much better if they had not been ported over from the sailboat market (the main home of M-32s).

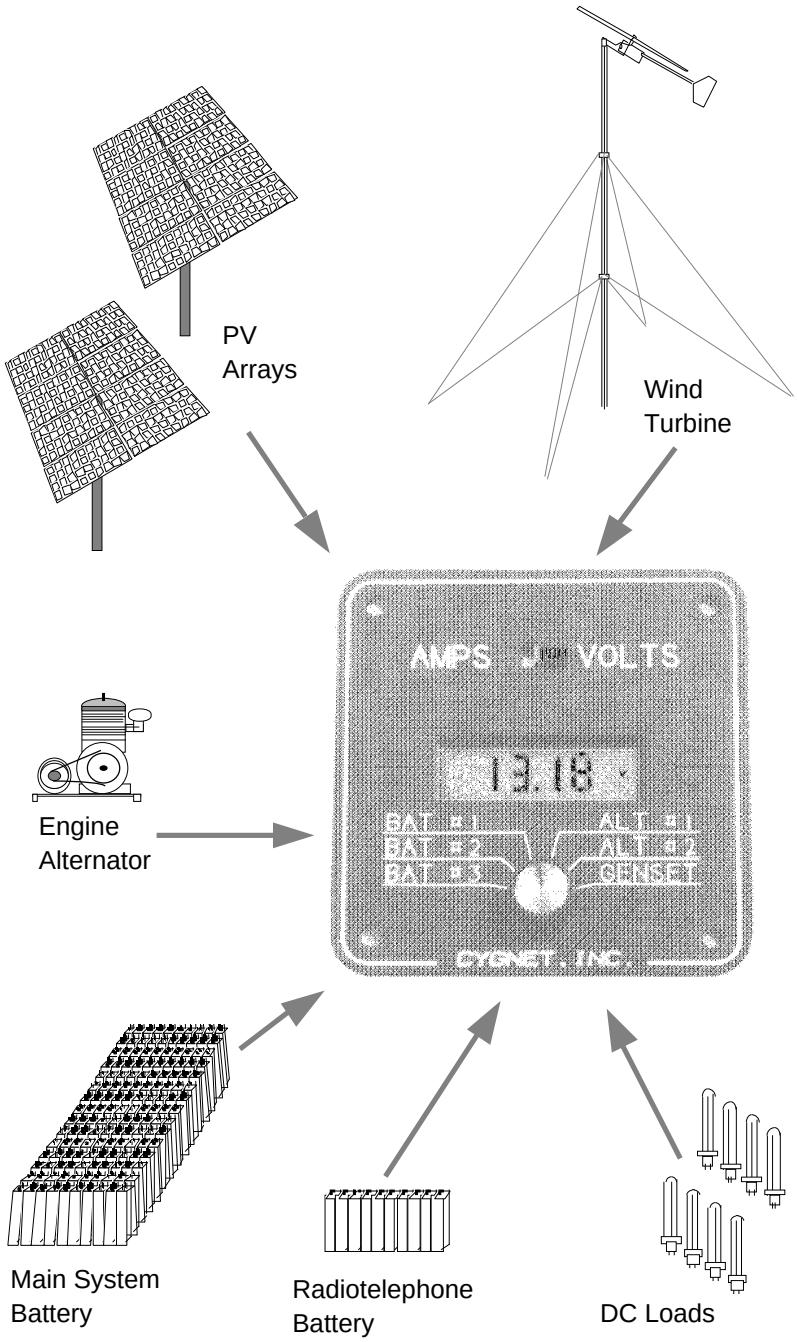
**The Cygnet M-32**
The actual instrument measures 3.2 inches wide by 3.2 inches tall by 2.0 inches deep. It has a six position rotary switch on the front which selects the place of measurement. There is also a two position slide switch on the front that selects either Volts or Amperes measurements. The M-32 uses a four digit LCD (Liquid Crystal Display) numerical display. The display has annunciators for Volts (V) and Amperes (A) as well as + and – annunciators. The digits on the LCD display are 0.3 inches tall. The instrument reads voltage to the nearest hundredth of a Volt (0.01 V) from 0 to 32 VDC. Current is measured to the nearest tenth of an Ampere (0.1 A). The rear of the M-32 contains fourteen wire hookup locations for all the various channels. The same model M-32 will work in 12 or 24 Volt systems.

The M-32 comes with two shunts for measuring current. The shunt is inserted between the positive pole of the battery and all input and output conductors. These are high quality, 200 Ampere, 50 milliVolt shunts (0.00025 Ω) with an accuracy rating of 0.25%. Each shunt contains small fuses for the instrumentation wiring. Extra shunts to fill the additional four current channels are available from Cygnet.

**The Test System**
I installed the Cygnet M-32 Battery Monitor in our system at Agate Flat on 13 August 1991 for testing. This system uses a pocket-plate, nickel-cadmium battery for storage. This system is sourced by several PV arrays (≈ 60 Amperes at 15 VDC), a wind turbine (800 W. peak, or 55 Amperes at 15 VDC), and a homebrew DC engine/alternator (1,500 W. peak or 100 Amperes at 15 VDC). We also use a second nicad battery system sourced by two PV modules strictly to power the radiotelephone. This test system abounds with instrumentation possibilities. Here a diagram of how it will look once I get all the channels connected.

**Test Results**
Both current (± 1.0% accuracy) and voltage (± 0.2% accuracy) measurements are within Cygnet's specification when compared to Fluke 87 multimeters. The M-32 monitor performs just as its maker says it will. We tested the M-32 in electrically noisy environments and in the presence of RF fields. It still worked accurately.

**Operating the M-32 Monitor**
The place of measurement is selected by the rotary switch and the mode of measurement (either Volts or Amps) is selected on the slide switch. It is all very simple and straight-forward. My only complaint about the M-32 is that I would like to have soft backlighting behind the display for night viewing. As it is now, I have to turn a light on in the room before I can read the meter. Parasitic power consumption of the M-32 was measured at 0.08 amperes or less than 0.1 Watts.




**Conclusions**

The Cygnet M-32 Battery monitor comes complete with two shunts for $229. Additional shunts are $24.95 each. The M-32 comes with a two year, repair-replace-or-refund warranty from Cygnet. While two hundred bucks may sound like lotsa money for a digital volt and ammeter, it is very cheap for six voltmeters and six ammeters. And that's what the M-32 really is– six digital voltmeters and six digital ammeters sharing a common processor and display. If you bought discrete instruments to make these twelve measurements, then you will spend over six times the money and probably not get the accuracy of the M-32.

Real estate in our instrumentation area was getting hard to find. We can only put so many instruments in a finite space. With the use of the M-32, suddenly we have lots of room left over.

**Access**

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Maker: Cygnet, Inc., POB 4353, Roche Harbor, WA 98250 • 206-378-5376.

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# Build an Odometer

Steve Willey



Selecting a site for a windmill can be risky. While the sun shines upon the just and the unjust, the wind only blows on *some* windmills. It is important to know how well a windmill is going to work on your site *before* you buy one and risk your life installing it. Unfortunately, a good meter to measure the wind available on a site and report the average speed each day cost as much as buying a small windmill. A few states (notably Oregon) had meters to loan available at state universities, but there was a three year waiting list to get one. So I designed a *very* low-cost wind speed meter that can be made from hardware store parts, costing under $30. It even calculates the average wind speed for the period since you last read the meter.

**The Meter's Design**

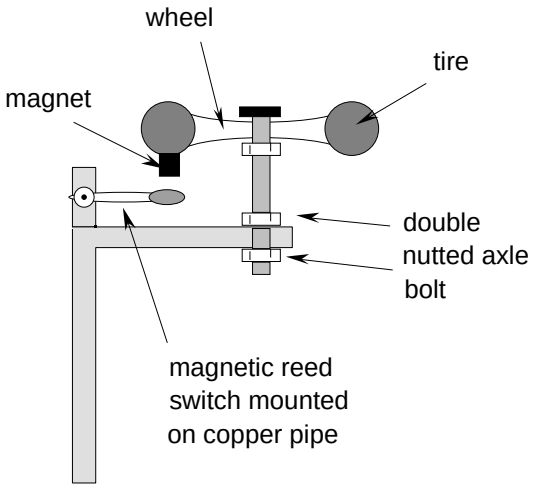
I made a three cup anemometer with much larger diameter than the little commercial ones. This results in slower turning and easier data collection. When tested on a mast above a vehicle driving on the highway, it seemed to rotate about 233 turns per mile whether the speed was 15 mph or 35 mph, so giving a reliable count of miles of wind passing. To count these rotations automatically, I attached a magnet to the rotating part, and a magnetic reed switch just below it so that the switch would activate once each time the magnet came around. I installed the anemometer on a pole above the house and ran 2 wires from the magnetic switch to a pocket calculator in the house. Once the wires were connected to the calculator, it counted 1, 2, 3, 4... on up to 999,999, as the anemometer turned in the wind, one count for each rotation of the anemometer. I let it count wind passing for 6 hours. Then I went to the calculator and divided (directly on the keys of the calculator!) the displayed count by 233 turns per mile. This showed MILES OF WIND PASSED during the 6 hours. Next, I divided that miles-of-wind figure displayed on the calculator by the 6 hours elapsed. The answer now showing on the calculator is the average miles per hour of wind for the last 6 hours. The calculator is cleared to zero and set to start counting for the next 6 or 8 hours.

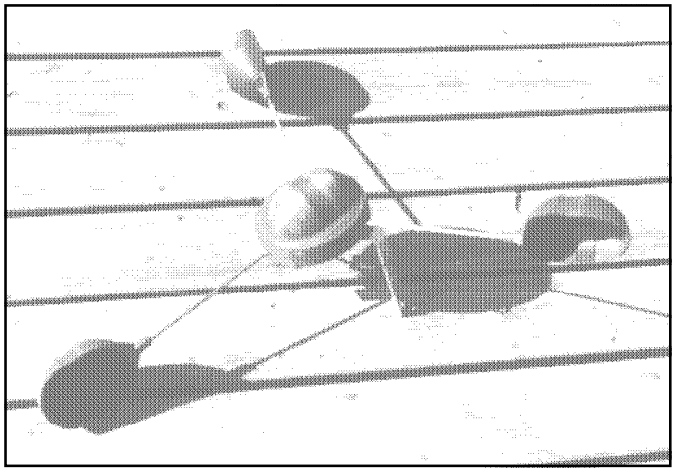
**Details: Anemometer Wheel**

The anemometer wheel is simply a 4 or 5 inch diameter ball bearing wheel with rubber tire available at hardware stores for under $10. Solid rubber tires are most desirable, but hollow ones work too. The wheel turns on a bolt double-nutted to a steel shelf bracket from the same store.

The cups are plastic toilet tank float balls cut in half, and mounted on the regular brass rods sold with the floats. The rods are threaded on both ends and will screw into the half float balls and the other end will thread itself into 3/16 inch holes you drill into the rubber tire. Be sure to drill all the way through the inside rim of the tire if it is a hollow one so the rod can be screwed fully into two points of support within the tire. Glue one of the cut-off float ball halves over the top of the wheel bearing to keep rain out (see photo)

A strong flat magnet should be glued to the underside of the rubber tire. The tire is the only place you may attach the magnet because steel will defeat the magnetic path for the reed switch. A magnetic reed switch can be





Above: the anemometer. Photo by Steve Willey.

purchased from Hosfelt Electronics (800) 524-6464 part number 51-108 for 25 cents, or 51-144 for 30 cents, or 51-145 for 50 cents. Get several in case of breakage since they are glass. Hosfelt has no minimum order amount for credit card or COD phone orders. (It is possible to use the Radio Shack door alarm magnetic switch sets, normally open #49-512 for $5.19 which includes both magnet and a switch with screw terminals, but it is oversize and bulky for this application).

The reed switch mounts below the tire where the magnet will pass. Again, to avoid defeating the magnetism for the switch, the switch cannot be mounted on steel or iron. To mount the magnetic reed switch, flatten a 6 inch piece of copper pipe, screw it to the shelf bracket and bend it so that the end rides just under one edge of the tire where the magnet will pass. Temporarily hold the switch on the copper arm with a rubber band while you rotate the wheel by hand. The magnet should pass within 1/8 to 1/4 inch of the switch. Listen for the slight clicking of the switch as the magnet passes, or connect a flashlight bulb and battery to the switch to confirm operation. It should light just as the magnet passes. Slide the switch back and forth and change its direction to find a location where it is most reliably activated only ONCE when the magnet passes. Check this at high and low wheel speeds. Using silicon seal or Goop brand glue from the hardware store, attach the switch to the copper bracket you made. Finally, attach wires to the switch, long enough to reach into the house. First tie or otherwise clamp the wire to the mounting bracket so it cannot pull on the connections at the reed switch. Then solder the wires to each terminal of the switch. The glass Hosfelt switches work best, but you must carefully hold the terminal between the soldering iron and the glass with needle nose pliers, and solder quickly to avoid breaking the glass with the heat. Get help if you are not experienced in soldering.

**The Calculator**

Calculators use several different keyboard input processes. This meter requires one that will count upward 1, 2, 3, 4, ... when you enter something like 1 + = = = = =, one count for each push of the = key. This is the most common type calculator, but a few will not do this. Try it before buying. Experiment with the + and 1 and = sequences, but it must be able to count upward with repetition of a single key after you start it with a simple sequence. Calculators that use gray (liquid crystal display) have much longer battery life than those that have red or green lighted numbers (LED display). But if you can find one that uses a 6 volt battery (4 AA cells) you can connect a lantern cell or even a golf cart battery for months of continuous service on one battery.

Finally, a larger calculator like an older one, or a desktop Sharp or Casio model will be easier to open and attach the switch wires into. Don't even try it with the very thin ultra-miniature or credit card types. A desktop printing calculator on which the printing function can be turned off has some advantages, since you can switch on the printer to record your wind speed readings on the paper tape, and switch it off to count again. Some Sharp brands I have used will print subtotals even when printing is switched off. This has a potential for automatic hourly total printing for those who want to experiment further.

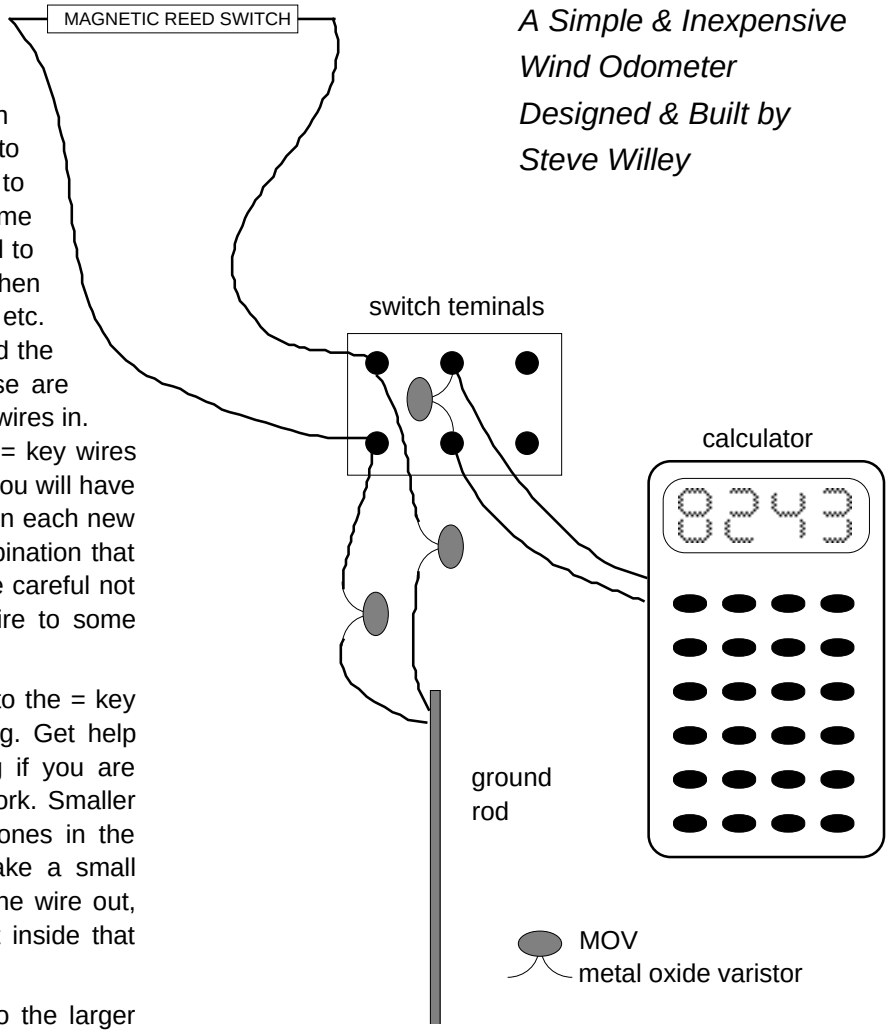
**Connecting Magnetic Switch Wires to the Calculator**

Carefully open your calculator. With luck you have spent only $8 or so for this unit, but be very careful and gentle with this process. The wires connecting the keyboard to the rest of the unit are usually all at one edge of the keyboard. Low and behold! There are fewer wires than there are keys. This is because combinations of wires are used, one for each horizontal row of keys, another for each vertical column of keys. Often these wires are bare, and easy to connect to, but if a ribbon type cable is used, you need to make your connections on the soldered side of the circuit board where the keyboard wires connect.

Presuming that your calculator counts up with each press of the plus or the equal key, as explained above, you need to connect the wires from your magnetic switch to the wires from that particular key. Once done, the magnetic switch on the anemometer will do exactly the same thing as pressing the key does. These correct wires will be the one from the row and the one from the column in which the = key is located. In case the wires cannot be visually traced from the key, you will have to turn on the calculator and experiment. Set up the sequence 1 + = =

*A Simple & Inexpensive Wind Odometer*
*Designed & Built by Steve Willey*

and see that it is counting ok as you press the = key. Then take a short piece of wire, and use it to connect from the first keyboard wire to the second and see the result. Then connect the first to the third and see. Then to the fourth. When the first wire has been tried to each of the other wires, repeat, this time connecting the second to the third, the second to the fourth, the second to the fifth and so on. Then the third to the fourth and to the fifth etc. Somewhere in those combinations you will find the same effect as pressing the = key, and those are the locations to connect your magnetic switch wires in. Of course most of those attempts to find the = key wires will cause entry of some other keystroke and you will have to clear and restart your 1 + = = setup between each new wire tried. In my experience, there is no combination that will damage the calculator, so long as you are careful not to slip and accidentally connect your test wire to some other part of the calculator circuit board.




Physically connecting your wind meter wires to the = key connections require careful and tiny soldering. Get help from a person well experienced in soldering if you are unsure, and use solder made for radio/TV work. Smaller solid wire, like the type used to wire telephones in the home is suitable to this miniature work. Make a small notch in the edge of the calculator to bring the wire out, and tie a knot in the wire that will support it inside that notch against pulling out.

These smaller gauge wires can be spliced to the larger wire from the anemometer a foot or two outside the calculator. At this point you need a switch to disconnect the anemometer when you use the calculator to figure average wind speed. Hosfelt part # 51-148 or Radio Shack part # 275-1533 or 275-1537 will do it. The switch will also provide a place to connect lightning protection. Test the meter now by starting the count sequence and manually spinning the wheel if there is no wind.

Lightning, or sometimes even thinking of lightning, seems to instantly fry the calculators. You won't want to unplug the wind meter in a storm just when the best wind is coming in. But it can be partially protected with lightning arresting Metal Oxide Varistors (MOV) by connecting one between the wires just outside the calculator, and then resting the calculator on a wooden table far from metal or other wires. Connect two more MOVs from each wire to a grounded metal water pipe or ground rod. (See drawing) These are available from Hosfelt Electronics, part number V8ZA25 for 50 cents each or V08Z2A3 for 35 cents each. Of course using a low cost calculator and having a spare wired ready to go is the best insurance. Test the counting again with the MOVs connected.

**Calibration**

Before installing at the test site, you will need to find how many counts per mile your meter gets. My 233 counts per mile is probably close, but it will depend on the size of the wheel, arms and cups and other factors. Run it down the road mounted on a vehicle to test it. Be sure to mount it horizontal, on a pipe mast preferably 6 feet tall off the front bumper so it will be above and in front of the vehicle to avoid air disturbed by the vehicle. It should give the same number of counts per mile from 8 to 30 miles per hour, when you drive one mile by the car's odometer or by highway mileposts.

**Installation**

Attach the mounting bracket to a mast with U bolt brackets or hose clamps. For wind measurement, the anemometer should be mounted at the same height

feet higher than all trees and roofs for 500 feet around it. If it is lower, you will miss some of the wind that a windmill would receive.

Start up the calculator with CLEAR, 1, +, = . When you want to read the meter, note the time elapsed since starting the count. You cannot use the calculator to divide the count while the anemometer switch continues its child-like pressing of the equal key several times each second, so turn off the anemometer switch first. Then with the count still displayed on the calculator, press divide by, and (your count number per mile), divide by, (your hours of elapsed time). The wind speed average should be on the calculator readout. Write it down and restart: clear, 1 + = and then reconnect the anemometer.

If you understand these calculations, try something that is even more fun. Instead of pressing 1 + = to set up a count, press 1 divided by 233 + = (but using your own count per mile in place of my 233. You might need to omit the + in that sequence too) It should then count in decimals of a mile, 0.001, 0.002, 0.003, 0.004, etc., reaching 1.00 after about 233 counts. You should set the calculator to use as many decimal places as possible. If it is a financial desktop type avoid rounding off the data to two figures. The count reading now comes up on the calculator directly in miles of wind passed!

**Measurements Needed to Evaluate Your Site**

A measurement of how many miles of wind passing is the best primary data. Miles of wind movement divided by the hours it has been blowing, gives the average miles per hour wind speed during that period (miles divided by hours = miles/hour).

Measurement periods between checking the meter should be short, perhaps 4 to 12 hours, based on your typical duration of more or less constant wind speeds. A meter that is checked only once a day may tell you that the average wind in the last 24 hours was 8 miles per hour. You need to know if that was 8 mph all day or if it really was 16 mph for 12 hours and 0 for the remaining 12 hours. Both give the same 24 hour average speed, but the former generates nearly no power at all while the latter gives quite good generation of power for 12 hours. Taking the average wind speed reading twice a day would show that difference; reading every 6 hours would give even more accuracy. This method of recording wind speed is a lot easier to live with than a direct SPEED meter that requires close watching all day to mentally average the speed each hour.

Once you have a good account of the wind speed distribution over preferably a full year, you can go to the charts in wind generator literature and figure just how much power each model would have produced had it been installed where the wind readings were taken. You then know exactly which wind machines, if any, would meet your needs, and which would not.

**Access**

Author: Steve Willey, Backwoods Solar Electric Systems, 8530 Rapid Lightning Creek Rd., Sandpoint, ID 83864 • 208-263-4290

Have you checked your mailing label?
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# Tech Notes:

## Hoxan PV Test Erratum

David W. Doty

Joel Davidson contacted me recently and pointed out an error in the PV Modules Test article in issue #25. The rated Voc for the Hoxan PM-50 modules should be 21.5 volts (not 24.5). I checked my spread sheets after talking to Joel and discovered I had made this error on one of them. Unfortunately, this must have been the sheet that Home Power copied the rated values from. Sorry about that!!

Joel was quite interested in the module testing and requested copies of my data, which I have sent him. He will be forwarding this information to the engineers at Hoxan.

**Access**
David W. Doty, 14702 33rd, Ave. NW, Gig Harbor, WA 98332 • 206-851-2208

*Our apologies to Hoxan and Photron from Home Power. Dave indeed did have the correct data on all but one sheet, the one we entered into the computer. The correct rated open circuit voltage for the Hoxan / Photron H-4810 PV modules is 21.5 Volts. The correct percentage of rating figure displayed in the spreadsheet is 89.3% and I have reprinted the table with corrections here.*

*We encourage independent field testing of PV modules and welcome this data within these pages.*

*Richard Perez*

Hoxan/Photron Label H - 4810/PM 50

| | Rated Value | Average Measured Value | Percent of Rated | |
|---|---|---|---|---|
| Isc | 3.30 | 2.95 | 89.5% | Amperes |
| Voc | 21.50 | 19.20 | 89.3% | Volts |
| Pmax | 49.50 | 39.44 | 79.7% | Watts |
| Vpmax | 16.50 | 15.06 | 91.3% | Volts |
| Ipmax | 3.00 | 2.71 | 90.5% | Amperes |
| PV Temp | 25.00 | 40.38 | 161.5% | °C. |
| Insolation | 100.00 | 103.14 | 103.1% | mW/sq. cm. |

## Nicad Battery Voltage Regulation

Richard Perez

I've been getting a lot of mail on the subject of where and how to regulate alkaline batteries. Many of us are now using large capacity nicad or nickel-iron batteries. Here's what we've been finding out about flying nicads. This info pertains to using ten series-connected, pocket-plate nickel-cadmium cells to make a 12 Volt battery.

**Voltage Regulation**
In almost all cases we have to regulate the system not for the sake of the battery, but to protect the appliances. For example, most 12 Volt inverters will shut off at about 15.3 VDC. At moderate rates of charge (less than C/20), ten series nicads will attain a voltage above 16.5 VDC when fully recharged. In order to keep the inverter from shutting itself off, we have regulated the system at around 15 VDC. This keeps the inverter working and protects voltage-sensitive, 12 Volt gear such as TVs, radios, and fluorescent lights. Eventually we will have equipment that is compatible with the slightly higher voltage profile offered by the alkaline battery. Right now, the best performing inverter for alkaline battery use is the PowerStar UPG models. They will run up to 16.5 VDC.

Regulating the system at 15 VDC doesn't mean that the battery never fully refills. It will continue to recharge, but at a slower rate. Eventually the nicad battery fully recharges, but it just takes longer. It is possible to float charge ten series nicads at about 13.3 VDC. They still refill at this low voltage, but the process takes days instead of hours.

We have been using series type controllers,especially the Heliotrope CC60C, with great success. Get a control that can go into the upper voltage ranges so that you can open the system up at a later date.

**A Working Voltage Profile**
Consider the following voltage data for pocket-plate cells:

•The pocket-plate nicad cell will happily float charge at 1.35 VDC.

•If you want a fast refill (>C/10), then you must open the system's voltage up to at least 1.65 Volts per series connected nicad cell. This means 16.5 VDC for a 12 Volt system ten series cells), and 33 VDC for a 24 Volt system (twenty series cells).

•Voltage regulation in the range of 1.48 to 1.50 VDC per series connected cell is just fine with the nicad cell. While it refills less quickly, it refills none the less.

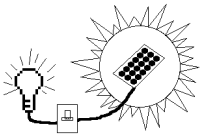
**A Major Advantage of Regulation**
We learned this by actually regulating our nicad packs and keeping data on their performance. We noticed the following side benefits of regulation at 1.50 VDC or less per series connected cell. The cells rarely spent much time gassing. This meant less distilled water replacement. Less gassing also means that the mineral oil layer floating on top of the electrolyte was not disturbed as often. This means that less atmospheric carbon dioxide is being worked into the electrolyte and should greatly extend the periods between electrolyte replacements. In our experiences, these nicads enjoy loafing and may even last longer if we don't ride them too hard.

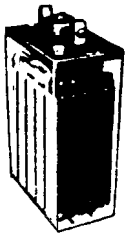
**A Lead-Acid Mentality in a Nickel-Cadmium World**
For years we've been very careful to fully recharge our battery. To do less meant expensive early battery death. For years we've watched the voltmeter, and lately the Amp-hr. meter, and wondered if we should start the generator rather than deep cycle the battery. For years we've been slaves to a cranky, temperature sensitive, short-lived battery technology.

It's going to take a while to get adjusted to a battery that does not care how we cycle it. In our experience, alkaline cells love deep cycling. They love shallow cycling. The love being overcharged. They love being undercharged. In short, they love being a battery. And I love having them as part of the Crew.

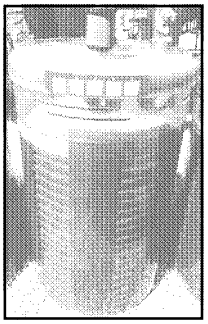
**Access**
Author: Richard Perez, c/o Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.







# Northwest Energy Storage



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*call or write:*

**Rob and Jean Shappell**
**Northwest Energy Storage**
**POB 137, Colburn, ID 83865**
**208-263-6142**
**208-263-8826 (shared FAX)**

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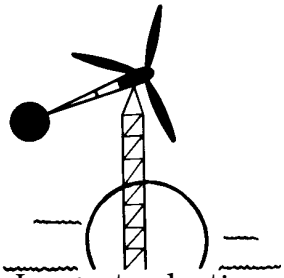
***Northwest Energy Storage–on the charging edge!***



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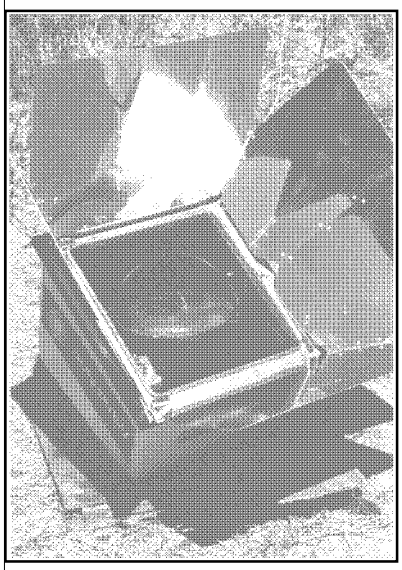

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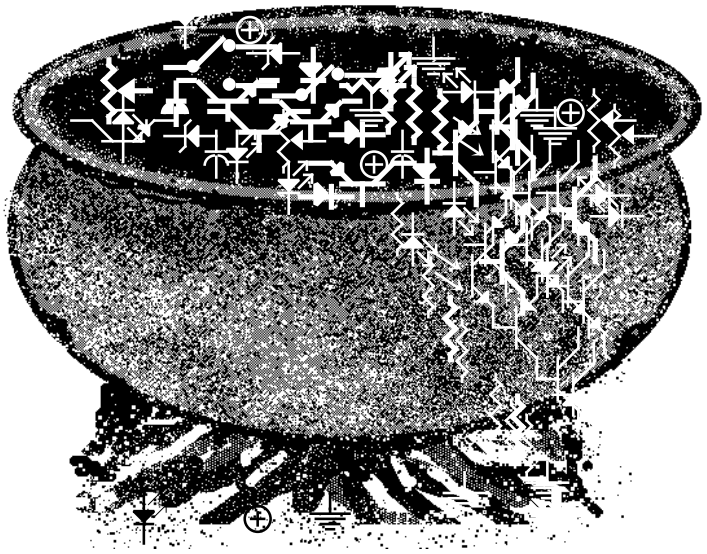
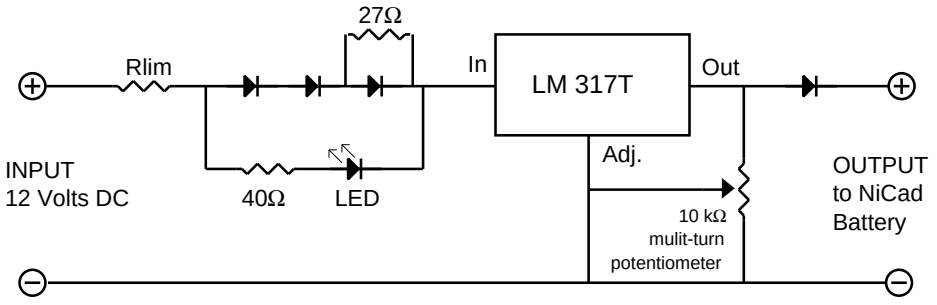
# Homebrew



## Wall Cube Replacement Circuit for Recharging Cordless Devices

Gerhard Dekker






Here's a nicad charging circuit that's cheap, simple and automatic. It will also tell you at a glance how the charging is proceeding. I've built one of these for every cordless gadget in my home (flashlight, vacuum, drill). The LM 317T voltage regulator (Radio Shack #276-1778) is carefully adjusted to maintain a tiny trickle charge current (2 to 5 milliAmperes) upon filling the nicad batteries.

To adjust, it is necessary to have the battery fully charged; this can be done by adjusting the regulator up to maximum voltage using the 10 kΩ potentiometer. Then only the current limiting resistor ($R_{lim}$) is holding down the current. Charge the battery until its capacity in Ampere-hours have been replaced. Then lower the voltage slowly by turning the 10 kΩ pot until the LED indicator just dims out. This will set the trickle charge current at between 2 to 5 milliAmperes.

After setting the circuit, return the appliance to the charger after each use. The indicator LED will show that connection has been made and the device is charging. At first, maximum charge current will be supplied to the battery. Maximum charge current is determined by the resistance of $R_{lim}$. When the battery is fully recharged the indicator LED will dim and finally go off. This circuit has worked very well for me. My flashlight, which I use every day, still has the original nicad battery after six years and it has not diminished in capacity.

To determine the resistance value of $R_{lim}$:

$$R_{lim} = \frac{\text{Supply Volts} - \text{NiCad Volts}}{\text{Maximum Charge Amperes}}$$

For my flashlight which used two AA cells (maximum charge rate 200 mA.), this works out to:

$$R_{lim} = \frac{12\text{ V} - 2.5\text{ V}}{0.200\text{ A}} = 47\ \Omega$$

**Access**
Gerhard Dekker, Box 689,
Steinbach, Manitoba, R0A 2A0
Canada • 204-434-6143

## Build a SunSighter

Mike Kilgore



PV arrays must be at the proper angle to receive the greatest amount of sunlight. The angle should be changed a couple of times each year to match the path of the sun across the sky during the different seasons. There are several ways to calculate the angle of the sun's elevation at any given time of year, but my way is easy and fast.

The sun's highest point in the sky is at noon, allowing for Daylight Savings Time if necessary. The PV array should be perpendicular to the rays of sunlight falling on it. In the past, I have adjusted my small array to provide the maximum charging current to the battery. That means having someone inside the house to watch the ammeter and tell me when I have it right. I decided there had to be a better way. The SunSighter was born.

**Construction**

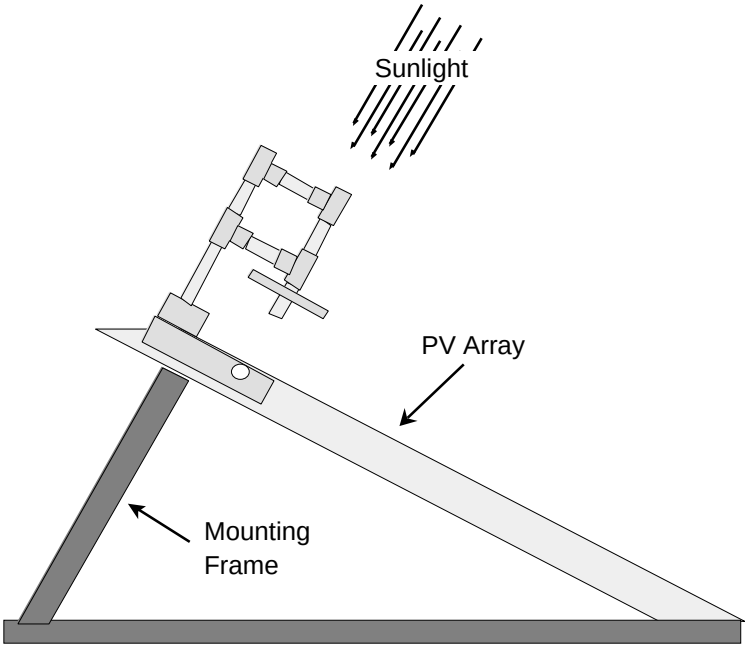
The base is made from two pieces of pine 2 x 4, glued together. After the glue was thoroughly dry, I drilled a vertical hole into the top piece of wood about 2 1/2" deep to accept the PVC tubing. I painted the base black so the circle of sunlight from the sighting tube will be easier to see. The shading plate throws a shadow on the base, making the circle of sunlight easier to see. I used 1/2" PVC tubing for the main structure but any convenient size of tubing will work. I then glued the structure into the base with waterproof carpenter's glue.

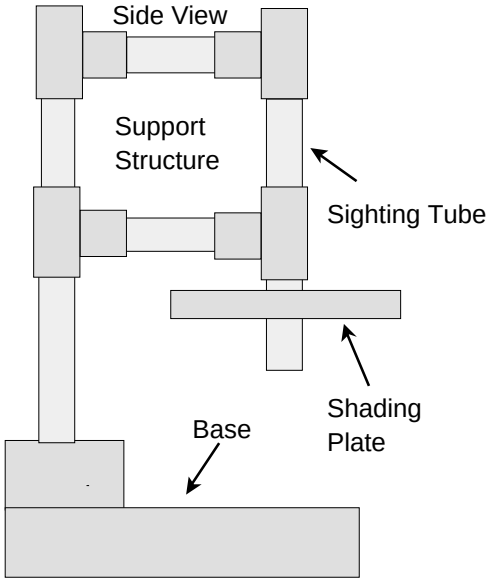
**Use**

The SunSighter is easy to use. Simply place it on the face of the PV array at noon (allowing for Daylight Saving Time if necessary) and adjust the angle of the array until the sunlight makes a bright circle through the sighting tube and onto the base of the unit. The user can also add a bit of wire to the base of the SunSighter to attach it temporarily to the edge of the PV array. This will leave both hands free to make adjustments.

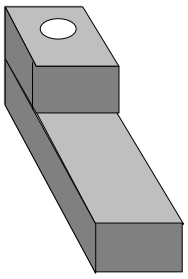
**Access**

Mike Kilgore, 2046 Ash Hill Rd., Carrollton, TX 75007

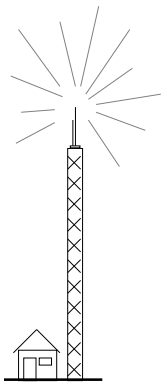



*The SunSighter*



Base Detail



# Recruiting Home-Powered Hams for a NASA Electron Beam Experiment

Michael Mideke WB6EER

excerpted by Karen Perez KA7ETV

A group of hams is recruiting help for a space shuttle experiment, due to launch on March 10, 1992. Space Experiments with Particle Accelerators (SEPAC) will be of particular interest to whistler hunters as it involves the operation of a plasma beam modulated at frequencies from below 1 kHz to 8 kHz to form a "virtual antenna" within the magnetosphere. The experiments, designed to investigate the nature of magnetospheric wave-particle interactions, may well generate whistler mode signals that can be heard by listeners on the ground. Ground stations will play an important role in the experiment. NASA has given the go-ahead for amateur and student participation.

**INSPIRE**

The ground station project is called Interactive Space Physics Ionosphere Radio Experiments (INSPIRE). They want to recruit a few hams who live beyond the power grid (radio-quiet sites) and can operate highly sensitive monitors with relatively little inconvenience. The group has prepared an E-Field receiver kit (receiver kit, instructions, demo tape, and follow-up mailings for $49.95) similar to the RS-3. However, there is nothing magic about the "kit" receiver–any system that works for hearing and recording whistlers is a potential contributor. Since the SEPAC transmissions will be harmonic rich, conventional receivers operating in the 10 to 30 kHz range will also have a place. Nobody knows whether ANY ground station will hear ANYTHING from SEPAC. However, the greater the number of stations and the better their coordination, the better the odds of success.

**How Can You Help**

For the project to reach its full potential, it requires a number of people contributing their time and expertise. How can *you* help? Perhaps you know of a school, class or instructor who should know about this. Maybe you could initiate student kit-builders into the mysteries of soldering and circuit de-bugging. Maybe you could scout vehicle-accessible quiet sites, or provide a few good cassette recorders, or use Ham Radio to maintain liaison between a monitoring group and the experiment. Maybe you could cook up a far better receiver, take it out to the middle of nowhere and come back with the best records of SEPAC. Maybe you could donate money or equipment...

**SEPAC Operations: FO7**

SEPAC constitutes but one small part of the ATLAS 1 mission, and the North American ground station campaign is only part of SEPAC's program. The part that directly concerns us is known as Functional Objective #7 (FO7). FO7 calls for the modulation of SEPAC's electron beam on a progression of 20 frequencies between 50 Hz and 7.04 kHz, beginning at the highest frequency. Each frequency will be occupied for 0.1 second. The interval between operations of the modulated electron beam varies along with the three beam power levels. At 1.45 kW the interval is 0.4 seconds. At 3.52 kW, it is 1 second and at 6.2 kW, 1.5 seconds. One minute is required to perform the stepped frequency progression at all three power levels. An FO7 operation will repeat the complete format 5 times, for five minutes of operation. In that time, the Orbiter will have traversed about 2100 km in a generally north-south path, pretty well covering North America.

**Ground Station Objectives**

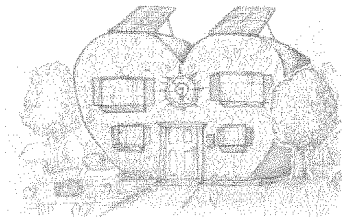
The primary objective of the ground stations is to determine the footprint of radio wave propagation from the pulsed electron beam in the ionosphere to the ground. Secondarily, the ground stations will attempt to detect any effects such as triggered emissions produced by FO7. In addition, they will produce a comprehensive record of VLF conditions before, during and after the experimental operation.

**And More**

We received a very detailed report about this project but unfortunately we ran out of room. If this small bit piques your interest, more detailed information can be had from:

Michael Mideke, WB6EER, Box 123, San Simeon, CA 93452-0123 (too remote to have a phone!) or Jim Ericson, KG6EK, 226 Charles St, Sunnyside, CA 94086-6063, 408-773-8947.

# Home & Heart



Kathleen Jarschke-Schultze

The big news at our house is that we now own a Sun Frost refrigerator-freezer. I am ecstatic. It has brought a whole new dimension to food preparation. I now have to *thaw* some foods before I can cook them. I can cruise the frozen food aisles at the supermarket and bring home ice cream and frozen peas.

**Harold**

Our old Servel, Harold, served us well in his time. Unfortunately, he never did freeze anything in a consistent manner. At the upper portion of the refrigerator, attached to the ceiling was a small aluminum box with a separate door. It was called the ice box. In my ignorance I believed that meant that food would freeze if I put it in there. After many attempts where things froze half way and ice cubes, if they froze, tasted weird, I came to a great realization. It is called an ice box because the ice builds up around the outside of the box, then you have to defrost it.

**Sun Frost**

Our new Sun Frost, an RF-16, is a wonderful appliance. The R stands for refrigerator, the F stands for freezer and the 16 means sixteen cubic feet of capacity. The refrigerator and freezer each have a separate door and compressor. There are door shelves. There is a light inside. Of the 119 color choices I chose "Hedgerow Green" kind of an ivy green. When I transferred the food from a full Harold to the Sunfrost, it only took up two shelves of space. I'm in love.

Because of the Sun Frost, I have used the defrost mode on my microwave for the first time. I made pesto and froze it in the ice cube trays so now I have the cubes in a bag ready to add to sauces, pasta, or pizza. I use a Seal-A-Meal® to freeze leftovers till I need them for a quick meal. The booklet that came with the Sun Frost claimed that veggies would stay fresh longer because of the higher humidity. They really do! If we don't finish all of a green salad one night, it is still crispy the next.

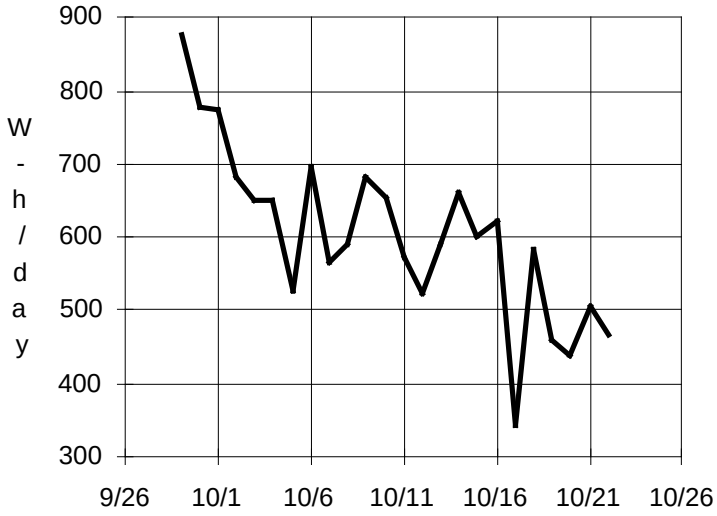
There is one drawback to the Sun Frost that I will just have to learn to live with. It is covered in Formica® so refrigerator magnets will not stick to it. This has not been a problem for me. Also I would advise reading the owner's manual, provided inside the Sun Frost, before you position and wire your model permanently in place.

**Power Use**

We were very curious to see just how much power was going to be needed to run the Sun Frost. Bob-O ran the wiring in conduit down to the battery bank direct so it is running on 12 Volts DC. After the initial start up, the compressors seemed to run all the time. It took about a week for the Sun Frost to cool down to its norm with the compressors running less and less all that time.

The graph below shows the energy consumption of our RF-16 since it went on line on 29 September 1991. Note the extra energy taken to cool down the refrigerator/freezer. The average exterior temperature around the Sun Frost during this period was 66.2 °F. After the box cooled down and stabilized, our Sun Frost has consumed an average of 44 Ampere-hours per day and average energy use was 574.3 Watt-hours per day.

*Energy Consumption of a Sun Frost RF-16*




**Food Club Update**

Chris Roth, an HP reader and solar chef, writes to inform us about another food distributor. Northeast Cooperatives, an Eastern equivalent to Mountain People's Warehouse, distributes throughout New England and the Northeast. Their address is Northeast Cooperatives, POB 8188, Quinn Rd., Brattleboro, VT 05304 • 1-800-334-9939 locally, 257-5856.

**Seeds of Life**

Adrienne Rice of Lopez, WA has written to tell me of a group dedicated to self-sufficient gardening. They are Abundant Life Seed Foundation, POB 772, Port

Townsend, WA 98368. They sell open-pollinated vegetable and grain seeds suitable for Pacific Northwest climates. They also stock seeds of hundreds of species of PNW native and naturalized flowers, shrubs and trees; seeds of native and non-native herbs; seed-saving supplies; and many books on nature, gardening, seeds, etc. Annual memberships are $10 (First Class, US).

Other folks she would like all readers to know about are Ronniger's Seed Potatoes, Star Route, Moyie Springs, ID 83845. Their catalog is $1 and contains the largest selection in the USA of organically grown seed potatoes.

**Solar Cooker #s**
Inadvertently the area code numbers for Solar Box Cookers International were transposed in the Access of my article on the Solar Gourmet® in HP #24, pg. 59. The correct access information is: SBCI, 1724 Eleventh St., Sacramento, CA 95814 • 916-444-6616.

**Access**
Kathleen Jarschke-Schultze, c/o Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3401

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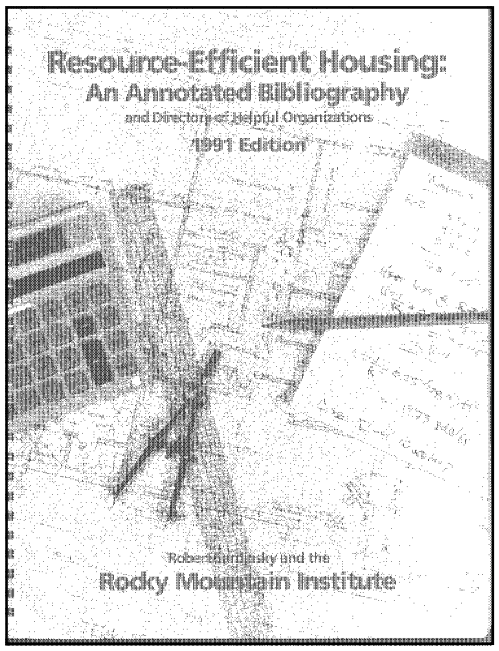
by Robert Sardinsky
and the Rocky Mountain Institute

Reviewed by Karen Perez




Have you ever wished for an easy way to find elusive information? Robert Sardinsky's bibliography is a wish come true.

Robert Sardinsky's well written guide directs you to over a hundred resource-efficient reference books, periodicals, organizations, and source books. The list includes titles covering resource-efficient housing design, construction, retrofit, energy-efficient house plans, landscape and site design, appliances, renewable energy, household environmental quality, shopping for and building resource-efficient housing, the owner-built experience, and more. The descriptions in this 161 page, spiral bound book gives you a real feel for what the material covers before plunking down your hard-earned money. An added bonus is a sprinkling of informative line art and thought provoking quotes.

To give you a feel for Mr. Sardinsky's concise style here is an excerpt from the introduction. "Our homes can make a powerful statement about our values, goals, and lifestyles. They tangible show, among other things, how we can, or cannot, live in harmony with nature. Though most 'modern' American homes provide us with unprecedented comforts, supplying these often wastes precious, non-renewable resources and wreaks havoc on the environment. Fortunately, we now have the knowledge and technology to rectify this. By building or renovating our homes to be resource-efficient, responsive to their surroundings and sensitive to this planet's finite resource base, we can not only live comfortably while honoring the other lives that share our world, but can also instill in our homes a sense of beauty, richness, and spirit. Bringing this to fruition, however, requires that we, in architect Tom Bender's words...put heart into our homes..."

If you are planning on building or remodeling your dream home, using renewable energy, or just want to get in touch with like minded organizations and schools, this book's for you. We have found this book a very useful addition to Home Power's library and you will too.

**Access**

*Resource-Efficient Housing: An Annotated Bibliography and Directory of Helpful Organizations* by Robert Sardinsky and the Rocky Mountain Institute is available from Rising Sun Enterprises, POB 1728, Basalt, CO 81621, 303-927-8051 for $14.95 + shipping, or from Rocky Mountain Institute, 1739 Snowmass Creek Rd, Snowmass, CO 81645-9199, 303-927-3851.

# HAPPENINGS

## The Big Island Renewable Energy Fair

Some of you will remember an announcement early this year for a renewable energy fair on the Big Island in Hawaii. Soon after announcing their plans the fair's organizers realized that they were unprepared for the task at hand and had to abandon the project, much to the dismay of those who had made an effort to contact them.

The good news is that a local business association has agreed to sponsor the event and plans for the fair are again proceeding. On February 8th and 9th, 1992 the town of Pahoa will be turned over to alternate energy specialists and their devotees. The Pahoa Business Association plans to make use of a recently completed by-pass road for access while closing-off the single street that traverses the town, creating a well serviced haven for pedestrians. Booths will be available along the street and within clusters set up in some of the town's vacant parking lots.

Hawaii's mild climate, abundant sunshine, over burdened utility and vast number of home lots not serviced by the grid have created a large market for alternate energy products. In preparation for the event local entrepreneurs are participating in the State's energy audit program. The town plans to use the expertise of fair participants by inviting specialists to tour the town and make suggestions as to how the town can become more efficient and self-reliant.

Those interested in the fair should contact the Pahoa Business Assoc. at POB 1189, Pahoa, HI 96778.

## Hands-on Solar Workshops

The '92 Solar Home Program at the Solar Technology Institute in Colorado offers a series of How-To and Hands-On Workshops. Learn to design and build state-of-the-art solar homes that are self-reliant, thermally efficient, healthy to live in, and environmentally conscious.

Passive Solar Design for Professionals-Jan. 13-23, Heating the Energy Efficient Home-Jan. 27-Feb. 20, Solar Building Skills-Mar. 2-Apr. 30, Practical Hydrogen-May 11-14, Advanced Micro-Hydro-May 18-21, Wind Power-May 26-29, Photovoltaic Design & Installation-July 6-17, Advanced PV for Remote Homes-July 20-30

These workshops are for owner builders and persons seeking careers as solar professionals.

For a detailed description of SOLAR HOME PROGRAM WORKSHOPS, costs and scholarship information; write Solar Technology Institute P.O. Box 1115, Carbondale, CO, 81623-1115 or call • 303-963-0715

## Hands-On Workshops in Maine

The Maine Solar Energy Association has started a series of hand-on solar workshops all around the state of Maine. The purpose of these practical, one day events is to de-mystify solar energy by showing the participants that it is practical today to use the sun to heat your home, make your hot water, furnish your electricity, and even cook your food and grow your vegetables out of season. In the past year we have had a very successful passive solar architecture workshop in Bangor, a solar greenhouse & sunspace workshop in Falmouth, and two photovoltaics workshops.

The participants of the photovoltaic workshops actually constructed solar cell modules that they could take home for the cost of the parts. Some people made small solar battery chargers. Several participants assembled large 35 watt power modules.

In the coming year the expanded schedule of workshops will include; solar air heating, solar water heating, solar cookers and ovens, solar electric home, passive architecture, greenhouses and sun spaces, and the immensely popular photovoltaics workshop. The fee for each of these workshops is $25.00, which includes lunch.

For information on sites and dates contact Richard Komp, Maine Solar Energy Association, RFD Box 751, Addison, ME 04606, 207-497-2204

## Electric Vehicle Club for Oregon

Lon Gillas of Pacific West Supply Co. in Amity, OR is organizing an electric vehicle club to promote electric transportation in the Pacific Northwest. Those interested in participating please contact Lon Gillas at P.O. Box 347, Amity, OR 97101, 503-835-1212.

## NE Sustainable Energy Assoc.

4th Annual American Tour de Sol, May 1992, solar and electric car championship. Contact NESEA at 413-774-6051

## Minnesota Energy Council

The MN Energy Council will hold a number of conferences on new technology in energy and environmental management for housing, small buildings,

small business and municipal buildings, aimed at professionals and business people. For more information contact: Roger Peterson, Minnesota Energy Council, Box 8222, St. Paul, MN 55108 • 612-378-2973

## Solar Electric Classes in Nevada

Solar Electric Classes for a max. of 4 students for more personal attention. Taught at remote Solar homesite. 2 day class, choice of 4th weekend of Feb., Mar., or April 1992. Class will be full of technical info, product evaluation, sizing systems, etc. Students will build a solar system. $75. For Info SASE to Solar Advantage, 4410 N. Rancho Dr. #148, Las Vegas, NV 89130, 702-645-6571

## North San Francisco Bay Chapter of the Electric Auto Assoc.

All interested persons are invited to the meetings of the North San Francisco Bay Chapter of the Electric Auto Assoc. The meetings will be held on the third Saturday of each month at the Citibank conference room in Novato, CA. Contact Andy Clary, 1710 Greeneitch Ave., Santa Rosa, CA 95401, 707-526-7692 from noon to 5 pm for meeting and membership information.

## American Solar Energy Society(ASES)

ASES has issued its call for papers for the June 13-18, 1992, SOLAR 92: THE NATIONAL SOLAR ENERGY CONFERENCE, Cocoa Beach, Florida. The conference is the 21st American Solar Energy Society Annual Conference and included the 17th National Passive Solar Conference. Papers are solicited which detail recent and current work in the field of solar energy conversion and utilization. For more information and a copy of the detailed Call for Papers, contact: American Solar Energy Society, 2400 Central Ave., Ste G-1, Boulder, CO 80301, 303-443-3130, FAX 303-443-3212

## Union of Concerned Scientists (UCS)

The Union of Concerned Scientists (UCS) has announced a year-long campaign to change the public perception of solar, wind, and other renewable energy (RE) sources. UCS will help people to plan and carry out educational and political activities promoting greater use of RE.

Although the public likes the idea of using RE most people, including industry leaders, utility planners, and government officials, think of renewables as futuristic, backyard novelties. In actuality, RE technologies could provide a much greater share of the nation's energy supply. However, current energy policies have prevented renewables from penetrating energy markets in a significant way.

The first step in changing the policies is to help people understand the tremendous potential if RE technologies. Public education will be a major focus of the "Renewables are Ready" campaign. UCS activists will also focus attention on policy-makers and work on changing the regulatory climate to encourage the growth of renewables.

If you would like more information on how to get involved please contact the Union of Concerned Scientists, 26 Church St., Cambridge, MA 02238, or call them at 717-547-5552.

## Sun Day 1992

Public Citizen and nearly 200 citizen groups (including Midwest RE Assoc., Great Lakes RE Assoc., Redwood Alliance, & just about every RE Assoc. and environmental group you can think of), businesses (including Jordon College, Snowbelt Solar, Lake MI Wind & Sun, Integral Energy, Solsource & Home Power), government officials and others announced plans to sponsor SUN DAY 1992: A Campaign for a Sustainable Energy Future. The organizations, located in 39 states and the District of Columbia, collectively represent over two million members.

The sponsoring organizations are advocating a national energy policy that, at a minimum, reduces the total energy use by 10 percent and tripling the current contribution of renewable energy technologies by the year 2010.

SUN DAY 1992 is a campaign primarily being built upon activities initiated by individual citizens and local and state-level groups rather than as a centrally directed and managed program. It will include at least one national day (Earth Day–April 22, 1992). The focus of SUN DAY 1992's sponsors will be developing local and state-level coalitions to advocate for policies supportive of SUN DAY 1992's goals.

Rather than just one-day, one-shot events SUN DAY 1992's sponsors will encourage, support, and launch ongoing education, attracting media support, organizing, and other activities before, during, and after Earth Day 1992. Some participating organizations will provide information, encourage model programs, legislation and government policies, lobbying Congress, hold conferences, and distributing information to grammar schools, high schools, and colleges.

For more information and to find out how you can help contact: Public Citizen, attn. SUN DAY 1992, 215 Pennsylvania Ave SE, Washington, DC 20003 or call 202-546-4996

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## *the Wizard Speaks…*

### Super Conductors

Super conductors are those elements or compounds, which below a certain temperature, exhibit no resistance to the flow of electrons. This temperature is called the critical temperature. This temperature is different for different substances.

A second factor affecting superconductivity is the presence of a magnetic field. For every temperature below the critical temperature there is a critical magnetic field strength above which the substance looses its superconducting property.

The third factor affecting a material's superconductivity is current density. For each temperature below critical temperature and each magnetic field strength below critical, there is a critical current density above which the material is not superconductive. Unlike the other two factors, critical current density can be increased by proper materials processing.

When superconductivity was first discovered it was thought to exist only within about 25° of absolute zero. (25 Kelvin or 248° Celsius or 415° Fahrenheit.) These temperatures were obtained through the use of liquid helium at about 4.2 Kelvin. Recently, materials have been discovered which are superconductive at temperatures above that of liquid nitrogen (77 Kelvin). The major drawback to these higher temperature superconductors are low critical magnetic field and low current density at liquid nitrogen temperatures. However, at the temperature of liquid helium they do have higher critical magnetic fields than earlier known super conductors.

Until now no wide spread commercial use of superconductors has occurred due to the high cost of liquid helium. If higher temperature superconductors can be developed and the problems of low critical magnetic field and current density solved, then they might become economically feasible due to the lower cost of liquid nitrogen. Some possible uses include energy generation, transmission and storage. Other applications exist in the fields of computers and electronics. Much research and development will be necessary in the near future to realize these possibilities.

# Letters to Home Power

We Print 'em Unedited.
Selected & Entered by
Kathleen Jarschke-Schultze

**My "Solar" assisted car**

Years and years ago I purchased a 25 watt PV panel for 12 volt use in our home. When that power system was expanded, the 25 watt panel was replaced with 8 ARCO M 53's.

As I contemplated a possible use for the original 25 watt panel I considered several facts. If gasoline engines are about 25% efficient, and auto alternators about 50%, then the conversion of gasoline to electricity would be about 13%. I then measured all the major electrical loads on my VW Rabbit, and figured that the 25 watt panel should handle the load.

I mounted the 25 watt panel on the roof of the car and ran the wires directly to the battery through a blocking diode. The actual mounting was accomplished with RTV.

Even though the panel protruded up into the air stream a good inch and a half, the gasoline mileage went up 7%. Most driving was short trips of 5 miles or so, and this meant more starter operation. To prove to onlookers that the PV panel was doing the job I disconnected all the wires from the alternator. Now the alternator was only keeping the belt tight on the water pump pulley. The car was driven this way about eight months. One December night I even gave a jump start to a fellow with a pickup truck. Finally on the 21st of December the battery gave out and I reconnected the alternator wires for the winter.

More recently the 25 watt panel rode atop a small pickup truck. Though I left the alternator wiring stock, it yielded a 5% increase in fuel mileage. This, while still using a framed PV panel which raised the aerodynamic drag. The original battery in this truck lived to an age of 8 years!

My most recent experiment is to use one of Photocomm's "duravolt" 25 watt unmounted panels on top of a '91 Subaru Justy. This panel has an unbreakable glazing which can be curved ever so slightly. I mounted the panel on the rear center of the roof and ran the wires down inside the rear hatch hinge gap. As can be seen in the photo, this made a neat, inconspicuous installation. With a panel thickness of about 10 mm there should be little additional aero drag.

Above: Nancy Laatsch & Solar Subaru. Photo by Randy Laatsch.

This front wheel drive Justy is EPA rated at 34 mpg in the city/39 hwy. So far (10,000 miles) the fuel economy has been about 39 mpg for trips of 5 miles or less, and the best has been 41++ mpg.

What remains is a full wheel alignment, and synthetic oil in the engine. Although the synthetic oil may yield small mileage gains, I will use, and dispose of less oil by doubling or trebling the distance between changes.

What should be done for new production cars? Engine and alternator size reduction is a place to start, (if it has to use gas) and the adoption of similar PV panels for electrical power supply. Maximum gains could be realized by regulating alternator output at about 13 volts and allowing the PV panel to "top off" the battery. Randy Laatsch, 11888 Wexford Pl., Maryland Hts., MO 63043

**Cool Condenser**

Dear Friends: I am writing to request a copy of the book Heaven's Flame. I have enclosed $10. Also please put me on the Oozie design newsletter. Its been a while since I looked at vehicle design (Ga. Tech Aerospace Eng 1972) lately I'm an AC power specialist with South Central Bell.

From that I can tell you and your readers that used TELCO batteries will be very hard to get ahold of due to the need for documented recycling of the hazardous material. That's of course good, but it would also be good to keep the cells in use rather than paying to get them recycled.

On using water to cool the condenser on a refrigerator, water cooled chillers are very common in commercial HVAC service. The existing condenser coil on a refrigerator is larger than would be required (designed) for a water cooled condenser on a factory model. It should work to drip (not spray) water down over the coil, and catching the water in a drain pan at the bottom. If you want to get fancy, you could wire up a solenoid water valve with the compressor to control (conserve) the water usage. The evaporative effect of the water would of course add to the efficiency of the unit but raise the relative humidity in the kitchen unless the coil was outside. Guess if it is outside you don't really need the drain pan either. (Just be sure to keep the condenser coil shaded all day.) Of course there are some places around where the relative humidity could stand some raising, but that thought doesn't occur around here. The amount of water needed would be very small. To figure the water consumption look at the spread of your available water temperature versus the room temperature. For each BTU/Hr your refrigerator is rated for, you're going to need 1 pound of water raised 1 degree F. (One of the few sensible areas for engineering in English measurements is heat transfer.) to allow for compressor inefficiencies, figure on 1.25 pounds. It works out like this: 1000 BTU/Hr refrigerator with water 20 degrees colder than the room will need about 8 gallons per hour or about 1/8 gpm. For the experts, yes, I know its the temperature between entering and leaving water temperature is much above room temperature, and efficiency is what the whole effort is directed toward here.

Anyway this will only really help where the unit is in an area (room) that is normally warmer than the available water by 5 or so degrees, again except for the evaporative effect.

To look at the evaporative effect (this will really help in hot and dry areas) remember that one pound (one pint) of water evaporated will take 970 BTUs of heat. That is about the amount of heat a refrigerator will move in an hour. Larry Bentley, KA5HKR, 905 Palm St., Jackson, MS 39212

**Compadre**

Dear Home Power Crew: You are doing a great job. I love your magazine.

I'm trying to give myself the time to write you a real letter feedbacking you lots of things from this very end of the world, that arose from reading and discussion of HPM articles and Q&A. More sooner than later I will do. When you are forced to find solutions far away from the supply of technology, many times, simple and cheap means of doing otherwise complicated and expensive tasks arise. I think we have things in common, we people who live in underdeveloped countries and you Home Power people in the USA.

Our fight here is to convince short-minded people that development and progress by no means is to follow the wrong steps of the so called "developed countries" that led into pollution, extinguished animals and a very unhuman way of life. I think the right way is to join those like you who are already "coming back" from all that, and are leading mankind in the right path. There's still a lot to save here from destruction. We should work together. Keep up the good work. Diego Lorenzo Gomez de la Serna, POB 52696 Correo Central, Santiago, Chile

*Thank you, Diego, for a wonderful letter. I congratulate you on your far-seeing awareness. I believe all people using renewable energy are working together towards the common goal of a cleaner earth. It makes our hearts glad to know you are with us. - Kathleen*

**Pump Power**

Dear Home Power, I am in the process of planning an alternative energy system for a cabin out in the woods. I have an idea that I would like some input on. I would like to use a Whisper 1000 wind generator that produces 120VDC. This would be used to charge a series of ten 12v deep cycle batteries. This idea seems worthy in that I can use inexpensive wire and the voltage would not need to be stepped up. I will still need an inverter to create AC from DC. A) Are there any reasons not to use a 120 volt power source? B) Would a mechanical inverter have any benefit in this system?

I have an old shallow well pump. I would like to know if it might work in a hydro electric system to convert the water flow into power. The vaned rotor is 4" in diameter. I connected it up to a garden hose - it started to spin with pressure. The reason I am motivated to use this instead of a turbine is because it has the potential of not having to be at the end of the run. I could install it "in line" and use the push and the pull of the water supply to create power. I could put the working parts of my system in a location that is both convenient and accessible. Sincerely, Ben Laughlin, 2288 Rt 414, Watkins Glen, NY 14891 • 607-535-4564

*No reason not to run your battery system at 120VDC, Ben. Just keep in mind that all your switches, fuses, etc., must be rated at 150 VDC or better. 120 VDC is just a nominal battery voltage. The actual voltage of a fully charged 120 V battery system will be pushing 140 VDC or more. Finding a 120 DC to 120 ac inverter is a little trickier. Try Chad Lampkin at Michigan Energy Works- (616) 897-5161. By "mechanical" I assume you mean a motor/generator type? They do work and have the added advantage of producing a true sine wave, but are pretty inefficient compared to today's FET based units.*

*Running a water pump "backwards" in a closed system as you describe can produce power, but unless we're talking about lots and lots of water, not very much. The push-pull that you describe only works if the water is flowing freely out the bottom end of the line at near zero pressure. That's fine if you are just using the water to fill a pond or something, but if you expect to use the water under pressure, you would be better off directing the tailwater after it freely exits your runner into a catchment and starting over from that point. - Bob-O*

**Solar Help**

Dear HPM Staff, Thank you for this great magazine! Please renew our subscription for two more years.

We have been off the grid since 1974 and we have been using solar electric since 1982, and we love both. My husband is disabled with multiple sclerosis. He has been working on some solar electric devices to help other disabled people be more independent in the backwoods. As I am pressed for time I will not elaborate now, but if anyone is interested I will gladly write more. Sincerely, Lu Marie & Michael Strickland, Dearborn Solar Electric Co., Rt. 1 So., Box 2364, Cascade, MT 59421

*We salute you, Michael & Lu Marie. Independence enriches any life, renewable energy enriches the earth. Keep us up to date on your projects - Kathleen*

**Ram Pump**

Dear HP, I read with interest the article in HP #23 on the high lifter pump. I agree that in many applications this pump is the best way to go. However, in the list of advantages there are some not always true statements. While in some situations the high lifter would be more efficient than a hydraulic ram, this would not be the case if the ram were installed correctly. I operated a business here in Missouri building, servicing and installing hydraulic rams for 10 years and am known as the local ram expert. We have used hydraulic rams to pump our water since 1979 and still do. The hydraulic ram water pump was invented in the late 1600s and is still used, mostly in developing countries where power is not available. In 1979 I attended a workshop on hydraulic rams at New Life Farm in Drury, Missouri where we designed, built, and tested over 10 different hydraulic rams. The efficiency of most rams we built was over 80%, with one model having an efficiency of 95%! The efficiency was measured by measuring the amount of water used to operate the rams times the feet of fall used to operate the ram to give us the number of foot pounds of water used. We then measured the pounds of water delivered times the height the water was pumped to give us the foot pounds of water pumped. Dividing the foot pounds delivered by the foot pounds used actual efficiency was obtained.

For example, one test used 40 pounds of water per minute with a supply head of 6 feet for 40X6=240 foot pounds of water. The pump delivered 5 pounds of water to a height of 40 feet for 5X40=200 foot pounds of water. The efficiency was in this case 200/240=83% efficient. Most pumps scored 90% or better. The only one less than 80% was the plastic pump published many years ago in Mother Earth News which didn't work at all, probably due to poor construction or materials. I used the design we decided on as the best for 12 months here at home using 15 feet of head pumping 75 feet before the impetus valve required replacement.

Using the figures in the article to calculate the efficiency of the high lifter as follows. Six gallons per minute and 26 feet of head gives 6X26=156 gallon feet of water used. Delivered is 0.166 gallons per minute and 132 + 26 = 158 feet height gives 0.166X158=26 gallons feet of water delivered. The efficiency for this application is therefore 26/156 = 17% efficient.

I definitely do not want to imply that the high lifter is not a good pump. I can see that in many cases it would be a better pump than a hydraulic ram. It does have many other advantages as listed in the article. An efficiency of 17% is actually very good for this type of pump. The efficiency of hydraulic rams can be this low or lower if improperly installed or if there is something wrong with the ram. If anyone has trouble with their ram feel free to call me at 417-683-3570. Written responses please include a stamped self-addressed envelope and $10 per response. For plans to build a ram from metal pipe fittings send $5. Dave Luckenbach, Rt 1 Box 393, Ava, MO 65608

**Solar Anthem**

Dear Home Power Persons: Here is the new Official National Anthem of the Solar Power Movement. The song is intended for solo and group singing at all gatherings of


one or more solar-minded energy-efficient people and their pets! This song is especially recommended for group singing whenever the TV news cameras roll during coverage of home power expositions wherever they may be held. Everybody join hands and SING!

The words are by the shy but talented wordsmith Joel Chinkes. The music is by Giacomo Puccini, a familiar tune of his from the very famous opera about what's-his-name, the sad clown.

## *O SOLAR MIO!*

*O Solar Mio!*
*Mi Sol Est Free-O!*
*Frio? Not Me-O!*
*Mi Sol Est Warm!*

*O Solar Mio!*
*Voltage For Free-O!*
*Photon Est Clean-O!*
*Free Am-per-age!*

*So Come!*
*Enjoy The Sun!*
*Clean Energy*
*For Ev-ry One!*
*(Repeat three times)*

 Yours truly, Joel Chinkes, Cincinnati, OH 45244

*I'm just guessing here, Joel, but before you were an HP subscriber you read MAD magazine regularly, right? - Kathleen*

*Jeez, another maniac crazed on PVP (PhotoVoltaicPower)! -Bob-O*

**Worldwide PVs**

This is a terrific magazine. I first heard about you folks through Real Goods and I am glad I subscribed. As a top shelf magazine, first class mailing is called for. Here at Maryknoll I purchase alternative energy commodities for our personnel overseas, especially in Tanzania where we have several photovoltaic Missions where electricity is needed for various usages such as running medical clinics. Here at Maryknoll my involvement at the present time is with the Burns Sun Ovens. This started out when I became interested in this type of project through trying out some of the VITA materials that were available many years ago when I was assigned to Bolivia. There my first experience was with a parabolic type of cooker that didn't work too well, but eventually we were able to bake some cakes in it. Keep up all the good work you are doing. Brother Theodore Flick, Maryknoll Fathers, POB 167, Maryknoll, NY 10545

*I have never tried a parabolic cooker but apparently it takes some finesse to use them. I am so enamored of the reflector style sun ovens that I haven't really pursued parabolic cooker research or testing. Although I still use my two cardboard Sunstar cookers, I received a Burns Sun Oven for my birthday. I love it. It's a nice tight, light efficient little unit. The benefits of solar cooking in under developed nations are obvious. Once you cook with the sun here in the States, the benefits of this cooking style will become obvious too. Good luck, good life and to borrow your own words, Brother, Keep up all the good work you are doing. Kathleen.*

**PV Performance**

Dear Home Power Types, re: your PV performance article (HP24). An impressive compilation of data. After looking at it a while it occurred to me that it wasn't telling me much about what I should purchase. If the specs that you focused on are typical of what manufacturers provide I would suggest that they are woefully deficient in the face of the real world applications. I have two suggestions:

1) A minimum derived quantity would be a power vs output voltage curve as this would allow for some comparative analysis if I know the operating voltage range of my batteries.

2) The obvious and most difficult to get would be the total A-H produced by an array as its illumination source is rotated from the edge on the right angle with the light source tracing through this 90° at a fixed rate. It seems to me that there is a big question of array performance not only at typical real world ambient but also at angles of incidence characteristic of real world applications.

re: Your article on instrumentation (#24). Too much data can easily bury a neophyte to the point of total confusion. As an occasional troubleshooter, I would like to add my take on data. When troubleshooting a malfunctioning system, historical data from known good times can be invaluable. Perhaps you could provide readers with some insight into the important bits of information that should be collected on a regular basis that would give them a "minimum system profile" to work with when troubleshooting. What data points do you rely on when troubleshooting? Regards, Ken Robart

*Hello, Ken. We supplied the voltage versus current curves for the modules because space didn't permit also printing the voltage versus power curves. Voltage is only really important in a module if there isn't enough to recharge the battery. Since most folks use static arrays, this is what we tested. PV output is roughly linear with angle of incidence. We took the measurements when the sun was perpendicular to the modules so that we would have the minimum 100 mW./cm$^2$ solar insolation.*

*We want to place computerized Ampere-hour instrumentation on the test array for a long period of time. Only problem is coming up with the some $7,000 worth of dedicated hardware for the project. If we can talk the industry or whomever into helping out, then we will be conducting long term Ampere-hour testing of PV modules. We need a Fluke Hydra and extra Mac to ride herd on it.*

*Sorry to have buried you in info. Give it a read through in several months and I'll bet it makes more sense because you have learned more. Array current is the one thing to watch on a regular basis. Folks who do this will know immediately when something goes wrong in the PV circuit. Constant monitoring of array current will also give the user a good idea of array power fluctuation caused by high air temperatures. Richard.*

**Dome Home**

Hello! As an AE novice, most of what I know about this field has come from reading HPM. My special interests are PV systems and electric cars. A friend and I are building a 1600 + foot geodesic dome - it's built on a raised foundation and is currently little more than an enclosed shell: has shingles, siding, windows and doors, but little else. Also have a 2-car dome garage. We live on a desert mesa (about 3500 ft) and thus far have experienced 98% sunshine. PV seems to be the sensible way to go! HPM is much appreciated! Dorothy L. Walker, 61870 Aberdeen Dr, Joshua Tree, CA 92252

*Good luck on your endeavor Dorothy, it sure sounds like you're in the right place for PVs and a dome. It sounds like a great site, although I wonder about water and gardening opportunities. - Kathleen*

*Hey, it's great to hear from dome builders. Karen and I built a 26 foot diameter, two frequency breakdown, octahedral dome here on Agate Flat in September 1970. We used a connector kit from the DynaDome folks and it went together in thirteen days with nothing but hand-powered tools. We affectionately call it the "DynaDump." After years of trying to stop all the leaks, we finally roll-roofed the puppy and gave it to Oozie, Karen's horse, as a barn. We learned several things about dome building. Domes do not tolerate funky carpentry, so make and use accurate jigs for all the parts. Domes are all roof, so if it can leak, then it most certainly will leak. Richard.*

**Vintage Vacuum**

Dear Kathleen & Co., I own a Kirby 509, which I bought, rebuilt, at an L.A. swapmeet in 1978. I have never seen another upright that can out-perform or outlast this one. When I moved into my (rented) solar/12-volt home a few years ago, I thought I would have to do without it, or save for a generator. The house came with a Tripplite PV-550 inverter, and I was pleased to discover that the Kirby works quite well on its "juice." Because of the square-wave output of the inverter, I usually run the vacuum for only a few minutes at a time, so it won't heat up.

Like the 505, this is a 3-amp machine, heavy, but small. I like the old fashioned cloth bag (always hated the wasteful, paper ones), and the hatch on the bottom makes it easy to empty.

Until I read your article in HP 23, I was not aware that it was still possible to get accessories. I am contacting the Sandersons for more information on this. Thank you, Kathleen for sharing this information.

On another track; it was a joy to connect with members of the HP crew at Seer'91. We even managed to fulfill a long-time ambition of mine, getting Richard and AEE's David Katz together for an interview for KMUD's Environment Show. As expected, the interview was quite lively and very well received. May the SPARK be with you! Arlo Hagler, POB 1194, Redway, CA 95560

*Thanks, Arlo. I like to hear about information from HP being utilized. I just love my Kirby (3 amp, 505), it performs flawlessy. Yes, SEER '91 was really great. It was a treat to be there, see you next year. - Kathleen*

**How about a Solar Traveler Network?**
"Long Distance Solar Voyager Network." X$ fee to join. Covers: Printing and postage for Solar Traveler newsletter. (Twice yearly or whatever) B) Advertising C) Solar Traveler Solar Transport Fest? (Sunfest?)

A network of solar vehicle owners who enjoy long distance travelling and would like to use their sun transportation to do so. Each member would receive a list of all other members and a map showing town locations of other members. Any member would be welcome at a fellow member's home to lodge and refuel for free or a small fee. All arrangements would be made prior to departing for journey concerning number of people if more than one, cost if any, and other details of that sort. What say? Other ideas anyone? For now, Love, Matheau David Moore, Bubela Press, 124 9th Ave., Pitman, NJ 08071

*How about it Solar EV folks? If you're interested in setting up a Solar Travelers Network, then drop Matheau a line. Richard.*

**Help!**
Several months ago, I received a letter from a fellow who had devised a tracking mechanism which was positioned by a clock and some kind of little magnetic actuator. This man sketched a mechanical diagram and a schematic, both on separate pages. Well, I have lost the schematic, which also has his name and address!

Help! If you're out there, I have begun to collect some of the parts, such as the 12v gearmotor, but I'm adrift w/out the rest of your info. Please help me out, and be so kind as to send me your drawings again. I will be forever grateful. Bill Barmettler, POB 1462, Chemalis, WA 98532

**Solar Pellet Stove**
As my latest project I have installed a pellet stove operated on solar power. It appears on a 3 day test that the system will work great, but will have to see what happens during long foggy periods in the winter months. I am using 2 Trojan L-16 batteries, a 700w PowerStar inverter, a Todd 75 amp charger and 6 used PV panels. The PV panels are 1 Tri-lam from Real Goods, 3 are M-51s from Alternative Energy Engineering. Used recycled PVs to try to save money on system. Putting out about 11 amps.

How do you get a hold of Windy Dankoff to answer a letter. I have written twice and got no answer in about three months. I need lightning suppressors. I really like your magazine. Gerald Ames, POB 749, Okanogan, WA 98840

*Keep us advised on your stove project, Gerald, it sounds very interesting. Windy Dankoff's phone number is 505-793-9699. Small business operators often have a difficult time answering letters. There just seems to be no time for that along with all the other duties involved. It is usually best to call the person, then if you catch them, you can get your information right away and ask any questions that may come up. - Kathleen*

**Eureka**
I can't tell you just how "juiced" I was when I picked up an issue of your magazine at a local bookstore and read 1/4 of it before I could even get out of the store. My finding this magazine was a complete fluke, since I went in to peruse organic gardening literature, but what a difference Home Power has made in my thinking. I live in the country in Central Illinois, where wind and solar resources are plentiful, and electricity is expensive. After thinking for a couple years about small or large alternative energy schemes, it's a shot in the arm to know that "there must be somebody out there doing this," and now I have a wonderful resource in your magazine. Already making plans. Thanks for the great articles which sent me back to my Physics books to freshen up and gear up for "off-grid" potential. Sincerely, Ginny Dahms, Rt 1 Box 88, Bement, IL 61813

*Yes, Ginny, we are out here and getting stronger all the time. You have joined some people surfing on a wave of sensibility and conscience. The information is spreading across the world. We have subscribers on all eight continents. Welcome. - Kathleen*

**Illuminating**
Dear Home Power, I wholeheartedly agree with Dan Freeman's call for RE to be used for more than just bare

essentials (#25). And I do not believe that this contradicts Henry David Thoreau's maxim: "That man is richest whose pleasures are the cheapest." But Dan's examples are terrible. Please consider your luxuries with great care.

For example, "lighting up the outside of your home." We should learn to respect and welcome the sanctity of the darkness of nighttime. To unnecessarily defile its character with outdoor lights is simply unconscionable. The heart breaking conflict between the environmental community and astronomers over the construction of an observatory on Arizona's Mount Graham is an example of our lack of respect for the night. There are so very few places of high altitude left that are not affected by light pollution. Turn off those outside lights!

I share Bill Barmettler's view (same issue) that most of us will make a gradual transition to RE while staying connected to the grid and so I encourage more articles about this approach. As I see it, it is a task of drawing RE supply and your demand together until they meet.

And yes indeed you should select some luxury items to be your first users of RE; to show to your friends and neighbors. Like your stereo. But do keep it turned low, or some of those neighbors might train air rifles on your PV panels. Sincerely yours, Hank Bruse, 235 Travis Dr., Wisconsin Rapids, WI 54494

*I learned maybe two things from surviving the '60s. One, no individual has the right to impress his will upon another. Two, be careful what you want because you just might get it. Richard.*

**DHW**

Dear Richard Perez and Home Power Folks, Thanks for the info on running computers off grid, and for starting my subscription to your excellent magazine. I received HP#25, and looked at Tom Lane's article on active solar domestic hot water (DHW) systems. I also saw bill Battagins's article about passive solar DHW in HP #22. These are great articles that provide valuable hands-on construction details.

However, while Lane's article is well-suited for solar-aware contractors, readers that are just learning about solar energy could be confused by a paragraph titled "Thermosyphons" into thinking that passive thermosyphon DHW systems are grossly inefficient and only partially heat up water tanks no matter how they are plumbed, as one reader I showed the article thought, when in fact passive solar DHW systems can be efficient and effectively heat up entire water tanks. Lane was not writing about passive systems, but rather about an active system with a passive component: he was saying that external heat exchangers should be avoided in active systems because they require two pumps instead of one, and that relying on passive thermosyphon currents instead of a second pump would greatly reduce efficiency and only heat up part of the water tank. Maybe the paragraph could have been titled "Avoid External Heat Exchangers."

Lane recommends water tanks with internal heat exchangers that can be purchased individually -- a great idea, and as far I know those are probably only available for active (not passive) solar DHW systems. (The difference between active and passive solar DHW systems is that active systems use pumps, and passive systems do not.) Some prefabricated passive systems do have water storage tanks with internal heat exchangers, but are only available as complete systems, including the collector. Can such passive tanks be purchased separately?

Tom Lane is a Gainesville, Florida contractor. He writes like there is no such thing as passive solar DHW systems, and in Northern Florida there probably isn't. I haven't been back there since I was an architecture and engineering student in Gainesville in the mid 1970s, when the only solar panels I saw in Northern Florida were at a state funded solar demo house. That demo house was where I first learned about passive solar DHW, by watching the classic simple open loop thermosyphon drain-down system in the backyard. I guess those must not have caught on in Northern Florida. Heck, you gotta be a farmer to remember to drain it down (other folks don't watch the weather so closely), and those systems haven't caught on in other U.S. cities either, where most solar DHW systems now being installed are as Lane describes (contractor-installed closed loop systems with PV-powered pump) or are prefab passive or active systems, many of which were displayed at SEER '91.

Bill Battagin's article on passive solar DHW responsibly covers only closed-loop systems, since those generally provide the most reliable freeze protection. In a closed loop system, the water to be heated does not actually pass through the collector. Instead, a secondary fluid (with anti-freeze and anti-corrosion properties) is circulated through the collector. The secondary fluid transfers its solar heat to your actual water through a heat exchanger tank (in Battagin's design, a home-made combination water storage tank with internal heat exchanger). Besides freeze protection, closed loop systems reduce scaling inside the collector if scaling is a problem with your water system, since the water does not come in contact with the collector.

Passive open loop systems, on the other hand, send the potable water through the solar collector. If the water in the collector stops flowing and freezes, even just for one night, serious damage to the collector will occur. To prevent such damage, one option is to drain the collector seasonally or on freezing nights. If you have frost sensitive crops that must be covered with cold frames or cloches, put them near the collector, so you remember to drain it when you are closing the cold frames. Another option is to put the bare collector (without its outdoor housing) in a climate protected area, such as in a greenhouse (this can also be done with batch collectors). Another option is to circulate warm water from the tank through the collector on freezing nights. This happens naturally in passive systems if the check valve is bypassed, but cools down the tank, should be done with backup heating disconnected, and is only suitable in mild climates or in sites that are drained down seasonally, and/or in locations with most water demand late in the day, and/or as a preheat for a gas water heater. And batch collectors (where the tank is the collector) also make good passive preheat systems.

For many passive solar DHW users, Bill Battagins's closed-loop system may be the answer. But building his home-made heat exchanger could be tricky (requiring the use of acid, protective clothing, etc.), and open loop systems can provide freeze protection in some cases, eliminating the need to build that heat-exchanger.

Here in Tucson, where I live Temporarily, almost any kind of passive design works, including a friend's seasonally drained-down open loop system with floor-level tank below the roof collector -- a passive system that wouldn't work in other U.S. climates. I work on solar DHW systems occasionally, and am interested in learning more about them, especially passive systems in climates that are cooler than Tucson. Thanks for covering solar water heating, an important technology that can be widely used on and off the utility grid. Sincerely, Carlos Portela, POB 43975, Tucson, AZ 85733

*Salute, Carlos. The problem with all of us is that we see only part of a problem. We arrive at what works for ourselves and feel we have discovered the truth. What we have discovered is part of the truth, but certainly it isn't all of the truth. We humans are provincial animals and only by sharing with others, who have different experiences, can we even hope to become more aware. Richard.*

**Back Issues**

The printing of your cumulative index in issue #24 was both welcome and tantalizing. Since I "discovered" your fine magazine too late to order a complete set of back issues, I could only wonder about what I had missed. In just one issue (#4) there are references to articles in issues 1, 3 and 5. I feel like someone with only some volumes of encyclopedia. I have a PC with modem and did see mention of availability in electronic form, but didn't understand all the details. I would gladly pay the cost of duplicating, postage, handling, etc. to get the information in issues 1, 3, 5, 6, and 7. Libraries in this area do not subscribe or keep back issues of this type of publication. Thank you for your time. Thomas E. Cannard, 309 Maryland Ave., Havertown, PA 19083

*Hi, Thomas. Many readers have requested more information on how to access and download out-of-print HP text and art files carried on FIDONET (HP25, page 93). Don Kulha of Sonoma Online, Santa Rosa, CA has promised an article for HP27 explaining all of the ends and outs of the process.*

*Call the phone number nearest you, do what the display on your computer tells you to, go to the selection of your choice, then select and read. Downloading depends on your particular software. The ECHO Conference is not in realtime. You enter your question and come back in 24 to 48 hours and check your messages. For those of you familiar with the process, here is the updated list of nodes. For those of you who are not, save this list and look for Don's article in HP27.*

FIDONET designator is HOMEPOWR
Chico, CA 916-891-1920 - Humanity Net
Chico, CA 916-345-4253 - Wildfire
Fortuna, CA 707- 725-5785 - The End of the World
Orland, CA 916-865-8462 - Cross Wind BBS
Santa Rosa, CA 707-545-0636 - The Outland
Santa Rosa, CA 707-545-0746 - Sonoma Online
Coventry, CT 203-742-7205 - The Reservation
Rockledge, FL 407-690-0032 - Energy BBS
Peoria, IL 309-672-4405 - Hacker's World
Temperance, MI 419-475-2241 - EchoMaster
Minneapolis, MN 612-341-8172 - Pro Photographer
Chapel Hill, NC 919-929-0677 - Earth-Net
Raleigh, NC 919-859-3353 - REDCON
Francestown, NH 603-547-6485 - Intervision
Hudson, NH 603-881-9741 - Cuckoo's Nest
New York, NY 212-947-0899 - Church of Human Dreams
West Islip, NY 516-321-4893 - EarthNet Hub
Pittsburgh, PA 412-466-9380 - End User BBS
El Paso, TX 915-591-1090 - Micro Applications
Seattle, WA 206-782-3365 - Helix

*See Ozonal Notes (pg. 94) for a possible way of getting out-of-print back issues of Home Power Magazine.*
*Karen and Therese*

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# Q&A

**Buzz, Buzz, Buzz**

Dear Home Power Magazine, I know you've reported on these inverters before, but I thought I'd update you on my limited, and somewhat disappointing experience, with the STATPOWER PROwatt 250 AC/DC inverter.

I teach energy education courses for classroom teachers. In my two day course we spend several hours discussing solar energy and doing experiments. I put together a small portable, yet complete, PV system for demonstration and experiment. The system includes a 30 watt PV panel connected to a 40 Ah 12 volt battery. The compact battery is nestled inside a carrying case with appropriate meters attached.

When I'm not in class I use the solar electricity to power my office. I carry the battery case into my office and hook up my Macintosh computer for about 3 hours of computing in the morning. Some of the equipment in my office does not like the inverter: 1) The transformer on my HP Deskwriter printer emits a barely audible but annoying buzz. 2) Every transistor radio I've tried experiences too much static or interference from the inverter, whether or not the radio was using it as it's power source. 3) The inverter also interferes with television reception and VCR playback.

Sometime in the next year I plan on installing a permanent PV system for my office. Will I continue to have these problems with larger inverters?

I have enclosed an Energy Education Course Description, which I offer through University Extension, Continuing Education, and to school districts.

Love your magazine and wishing you the best, Mike Arenson, Air 'N' Sun Resources, 142 Darwin St, Santa Cruz, CA 95062 • 408-423-8749

*You're not the first person that I've hear from that has experienced unacceptable noise and interference from that inverter, Mike.*

*While all inverters that I've seen and worked with emit SOME noise (especially in the AM broadcast band of transistor radios), few cause the severity of symptoms that you describe. Both my Trace 2012 and PowerStar UPG 1300 make an audible buzz in my Deskwriter transformer, but I had to get within 3 feet to hear it. It's not audible above the fan noise from my Mac IIcx CPU and it doesn't affect the printer operation at all. Either inverter will run the 19" color TV and VCR without interference. Proximity is always a problem with a high power switching supply, so try to put as much distance as possible between the inverter and your electronics when you make that permanent installation. Keep the inverter/battery leads as short as practical and twist them around each other if possible. - Bob-O*

**Hang 12**

I live 6 months/year on a small island on the Pacific coast of Mexico. Tides are about three feet. Does anyone have information or ideas on how to convert tidal or wave energy to 12 v? We now use only PV with a small generator back-up. Thanks for a great publication. Greg Plimpton, POB 14545, N. Palm Beach, FL 33408

*This is an interesting question, Greg. We were all sitting around Home Power Galactic Central awhile back discussing how all power came from the sun, whether it be wind, water or solar. "Ah," someone said, "but the tides are lunar." Try George Hagerman at SeaSun Power Systems, 124 East Rosemont Ave., Alexandria, VA 22301 • 703-549-8067 - Kathleen*

**One Man's Junk is...**

Dear Home Power Magazine, Enclosed find $20 for a 2 year subscription plus $3.50 for issue #25 which I am sure I missed by now. I also have two items I would like to comment about which follow:

1) I am a CPA and live in SE Nebraska. During tax season I am rarely home and don't have time to maintain and check a self supporting solar or wind system. What I'm interested in is a system that hooks into my present utility system and back feeds through the meter when producing more than I use and draws power when not producing enough electricity. This would eliminate batteries and a lot of maintenance. Nothing would make me happier than to receive a check back from my present utility company. What would be the best system for this? Who are the closest dealers? It must be simple as I am a novice at this.

2) Another item I am very interested in as I would think all of your AE and environmentally conscious readers would be is recycling. I never see any articles on recycling in your magazine. Maybe this is too far off the AE beaten path to be covered in your magazine. If so is there another magazine I can get to cover the subject?

I am seriously thinking about getting into this

commercially. I live on a farm and have plenty of room. I understand there is a company in Ireland converting all kinds of plastic into super wood.

Any information you or your readers could supply me on these two subjects would be much appreciated. Keep up the good work, as I love Home Power Magazine. Kenneth T. Reese, RR #1 Box 286, Nebraska City, NE 68410

*In Mike Bergey's article, "A Primer on Wind Generators," HP #22, he discusses this option under the subheading, "Being Your Own Utility Company." He says, "The federal PURPA regulations passed in 1978 allow you to interconnect a suitable renewable energy powered generator to your house or business to reduce your consumption of utility supplied electricity." He goes on to explain how these systems work and what options are available. You can contact Mike at Bergey Windpower, Inc., 2001 Priestley Ave., Norman, OK 73069 USA Tel: 405-364-4212 Fax: 405-364-2078 As to your question on recycling, Ken, I refer you to Garbage magazine. Also Earthkeeping magazine, POB 44, Luzerne, PA 18709 • 717-288-1567 - Kathleen*

**Sine Language**

Dear Richard, My friend Anita (who helps run our software business) and I went to SEER '91 in Willits, where we volunteered to keep the lectures at the Energy Independence Hall running smoothly (I also helped assemble the solar demo home). On Industry Day, we attended the Inverter Manufacturers Panel Discussion, where part of the discussion centered on the inability of inverters to power sensitive electronic equipment such as video equipment and laser printers. This might be important to us since we are a software company that may need to run computer equipment off the grid in the future and may need to give other people advice on how to do that.

The way I understood the discussion, the common inverters do not put out a smooth sine wave (from 120 VAC to -120 VAC 60 times per second), but instead put out a modified square wave, which is like a sine wave with the "stair case effect" (to borrow a computer graphics term). I do not use video equipment, but someone mentioned that modified square wave power causes interference in video pictures. I do use laser printers, and remember that some persons, including yourself, mentioned that laser printers could not operate on the modified square wave power. The inverter manufacturers said it would not be cost effective enough to develop and market sine wave inverters to the public since market demand would be minimal, but they said they would introduce new inverters that would produce a modified square wave with smoother curves (less of a stair case effect), and that these new inverters would run video equipment but not laser printers. You told the audience that would be no problem because laser printer users could switch to ink-jet printers, which I think you mentioned draw only 40 watts.

We pretty much need to keep a laser printer because our customers use laser printers (to print postal barcodes on envelopes) and we need to test the software on the same kind of printers our customers use. So I suppose that If I move off the grid I'll just use a generator to run the laser printer when I develop new versions of the mailing list software and need to test it. But I'll be keeping an eye out for any available information on how to run laser printers off the grid.

When I introduce our solar software, someone is bound to try to run it off the grid, so we'd like to find out more about how to run computers off the grid. Is there any source of information on that? Will you be covering that at all in Home Power magazine? (Note: I'll love your magazine even if you don't cover computers.)

For example, we have a friend who asked us about running computers off the grid. He is an accountant in mid-California with a pickup truck camper. He had an old portable Compaq computer with a 20-MB hard disk–a very common computer a few years ago, bigger than today's laptops but smaller than desktop PCs. It runs on 120 VAC and does not have any kind of batteries (it must be plugged in to run). Since he sometimes travels in his truck, he wanted to be able to run the portable Compaq from one of his two truck batteries, and to attempt to do that he purchased a small inverter from Real Goods. As he told me, the Real Goods catalog shows a picture of someone near a beach using a Mac in their car with that inverter. However, the computer refused to even boot up when he did plug it into the portable inverter. Figuring that maybe there was too much line-loss (voltage drop), he connected the inverter directly to the battery with big cables. Then he would get the computer to boot up, but it would crash (turn off, lose power) after a few minutes. He just couldn't get it to work.

Recently he purchased a Goldstar laptop computer: a 386 with a 40-MB hard disk. He called Goldstar technical support to ask them if he could run the computer on the inverter, and they told him they've never tried it and that if he tries it and it causes damage to his computer the warranty will not cover that. So he has not and will not attempt to run the laptop on the inverter.

I heard a rumor that those portable inverters have a real square wave (not even modified to produce a staircase effect). But I can't remember where I heard that and it might not be accurate. In any case, I hope to find out more about how to run computers on alternative energy. Sincerely, Carlos Portela, 3-D Software, POB 43975, Tucson, AZ 85733

*We've had readers express good results by using a Shape Line Tamer® (available from Photron, see their ad for access) between their inverter and laser printer, Carlos. Apparently, they're a bit noisy and will reduce inverter efficiency by 20% or so, but if they do the job... It sure sounds like your accountant friend bought an inverter that was too small to handle the power requirements of his Compaq. Contrary to what most folks think, computers are some of the least fussy and easiest loads for inverters to run. That's because they don't use the 110 vac directly, but transform it down to 5 VDC to run the ICs and usually +12 and -12 VDC to run the drives, etc. During the step-down process, they also filter the heck outa the input power. The filtering nearly always eliminates the "noise" on the ac line, whether it's caused by the inverter or the grid. Too bad Goldstar is afraid of what they don't know. The four Macs that are used in the direct production of HP day in and day out have never been fed anything BUT inverter power! I know of IBMs and lots of clones that digest it just fine with no problems. - Bob-O*

*Carlos, check out HP#16, pg. 7. This article is about Home Power's system. Most of the 5 kWh we cycle daily goes into computers and peripherals. Included in this article is a detailed list of computer gear that works well on inverters. In general, computer gear has less problem digesting inverter power than most consumer electronics. Just like all appliances, power consumption varies widely with type. Sounds to me like your friend had a big power consumer tied to a marginal car battery. Plugging a new computer or peripheral into the inverter for the first time is alway thrilling. We keep close track on problems like those with the laser printers. Filtration, like the Line Tamer, works on some lasers, but it cost money to buy the filter and it takes power to run it. These filters are mondo phantom loads, so be sure to switch them off line when they are not in active use. Meanwhile, we are happy with our Hewlett-Packard DeskWriter printers. They love inverter power and consume only 26 Watts while printing and 4 Watts on standby. They also cost about $500, which is much less than even the cheapest laser printer. As far as the quality of the DeskWriter's output, you tell me. You are reading it right now. We used a DeskWriter to print the masters for this issue. Richard.*

**3-in-1 Gas**

I really enjoy your magazine. I am just beginning to understand some of the methods of producing your own electricity environmentally safe. In beginning to set up, could a person use methane gas to run a generator? I have read somewhere where China uses methane to heat their homes, cooking, run the vehicles, etc. Am I correct in this? The lower portion of the tank was used for fertilizer, 3-in-1 purpose. William J Catlett, RR #1 Box 186, Monticello, IA 52310

*Although I do not know about the Chinese use of methane you are in luck, Will. I refer you to Al Rutan's article on home methane in this issue on page 24. I hope it will enlighten you as it has me. - Kathleen*

**Battery Box**

Dear Home Power, I'm two miles "from the grid" and am approaching the purchase of a small PV system from the position of a "well read, armchair, soon to be PV user." In other words, I've read Davidson's and Fowler's most recent books, pored over piles of catalogs, gone to SEE working systems, and finally feel educated enough to purchase and install my own system.

My one question is how to keep my batteries at an optimum temperature, say 65°-70° F, in a house (cabin) which goes unheated for 3-5 days at a time. Utilizing solar heat is not practical for the next 1 or 2 years. My plan is to build an insulated and vented "box" for the batteries. Inside the box I'll put a light as a heat source and control it with a temperature sensitive switch. Comments? Clay Turnbull, Simpsonville Brook Rd., Acton Hill - HC 33, Townshend, VT 05353

*That light bulb idea is asking for trouble, Clay. As lead-acid batteries become discharged, the electrolyte will freeze at higher temperatures. A fully charged lead-acid battery won't freeze until -60°F or so, but at 25% state of charge you're in trouble below +5°F. Totally discharged lead-acid cell are goners below +32°F. Suppose it snows the whole 5 days you are away from the cabin? The light bulb attempts to keep the batteries warm and totally discharges them in the process.*

*The best solution would be to use alkaline (nickel-cadmium or nickel-iron) cells in your system. They will deliver full output at 32°F. They will only roll off 20-25% of capacity at below zero, and won't freeze above -55°F regardless of the state of charge. Even if alkaline cells do freeze, they are not damaged and will work fine when thawed out. Richard & Bob-O.*

# Ozonal Notes

**Subscription and Mailing Dementia**
We get many second class subscriptions from folks who want us to start their sub with a back issue(s). Sorry, folks but we cannot do this. The reason is mailing cost. If we send your copy out with the regular issue's mailing, then we can stay alive for ten bucks a year. If we send your issue out as a single copy, it must be mailed First Class, and the cost increases over 600%. So, sorry but we must start your second class sub with the next regularly scheduled issue. If you want back issues of Home Power, then they are for sale at the cover price and that includes First Class postage. See page 95 opposite for availability and prices. If you want a copy of #10, then move fast because there are only fifty left.

While on the subject of Home Power's rapidly disappearing back issues (#1 through #10), would you like a bound book? We are considering two options–which would you prefer:

1. Reprint the old masters just the way they were (funk, old ads, and all).

2. Collect the info by subject, add extra stuff, and print it as a bound book with no ads.

Would you like the book to be paper bound or have a hard cover? And finally, what would you pay for such a book? Let us know what you want.

**It's ten o'clock.**
**Do you know where your mailing label is?**
Check out your mailing label. It tells you when your HP sub expires. We don't send out renewal notices, so we print your sub info on your mailing label. Check it out.

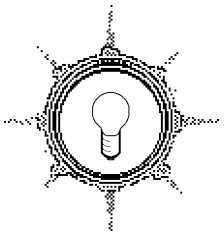
**People**
I want to welcome two new people to the Home Power Crew. First is Therese Peffer who has joined up full-time. It's thanks to Therese that this issue contains an all time low number of typos and English boo-boos. Her thoroughness and new perspectives make HP a better mag. Second is Paul Wilkins who has become HP's Video Editor. This crusty character has been cruising America in his PV-powered, VW portaslum for years. We are deliriously happy to have his help with movin' pitchers.

In the past four years, HP has grown from no one full-time, to four people full-time and one part-time. We, like the rest of the RE industry, are growing. Thanks to you, our reader. You are inspiring, you write us wonderful letters, Thanks.

Love and Sunshine,
*the HP Crew*

# Home Power's Business

"The man who on his trade relies
Must either bust or advertise."
Thomas Lipton - 1870.



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| Half Page | $672 | 33.8 sq. in. |
| Third Page | $480 | 22.5 sq. in. |
| Quarter Page | $377 | 16.9 sq. in. |
| Sixth Page | $267 | 11.3 sq. in. |
| Eighth Page | $214 | 8.5 sq. in. |

Maximimum Vertical Ad size is 9 inches
Maximum Horizontal Ad size is 7.5 inches

We can set up and lay out your display ad. Camera ready advertising is also accepted. For full color ad rates and demographics, please call us.

Long term display advertising is discounted, so buy ahead and save 10% on 3 insertions and 15% on six.

Home Power is published bi-monthly. Ad Deadline for the Feb / Mar 92 issue (HP#27) is 9 Jan 1992.

Call **916-475-3179** for further details.

## Mercantile Advertising

One insertion per customer per issue.
We typeset all ads. We do the best we can to make your ad look good. If you send too much copy, then you're bound to be disappointed. Flat Rate $80.
Advance payment only, we don't bill Mercantile Ads. Your cancelled check is your receipt.

## MicroAds

MicroAd rates are 10¢ per character. Characters are letters, numbers, spaces & punctuation marks.
$15 minimum per insertion. Send check with your ad. We don't bill MicroAds.

## First Class Home Power

Home Power Magazine (6 issues) via First Class U.S Domestic Mail for $25. Many of you have asked for faster delivery of your issues. So here it is: FIRST CLASS HOME POWER. All First Class issues shipped in an envelope. We start your sub immediately.

## International Subscriptions

Due to the high cost of international mailing & packaging, we must charge more for copies of Home Power that are mailed anywhere that doesn't have a US ZIP CODE.

**1 YEAR- 6 ISSUES**
**INTERNATIONAL RATES:**

Canada: Northern Alternate Power Systems, POB 14, Pink Mtn., BC V0C 2B0. $22. Can.
Mexico: Air- $16. Surface- $14.
Central America, Bahamas, Bermuda, Columbia and Venezuela: Air- $21. Surface- $15.
South America (except Columbia and Venezuela), Europe, North Africa: Air- $27. Surface- $15.
Asia, Australia, New Zealand, Pacific Ocean Islands, Africa (other than North Africa), Indian Ocean Islands, & the Middle East- Air $34. Surface $15.

**All payments in U.S. currency ONLY!**

Surface shipping may take up to 2 months to get to you. All issues shipped in mailing envelopes. If you have friends with a US Zip code who regularly send you packages, then we can ship them a copy for forwarding to you for $10 U.S. annually.

## Back Issues

Back issues through #20 are $2 each ($3 each outside U.S.), while they last. Sorry, no more Issues #1 through #9 are available, except a few #4. Back Issues of #21 through #25 are $3.50 each ($5 each outside U.S.). All back issues shipped via first class in an envelope or box.
Home Power Magazine, POB 130, Hornbrook, CA 96044

## Home Power Magazine for Resale

Quantities of Home Power Magazine are now available for resale by newsstands, bookstores, energy businesses, and others. Please write or call for the specifics.

## Second Class Home Power

Home Power Magazine (6 issues) via Second Class U.S. Domestic Mail for $10. Second Class is forwardable, but please let us know if you move! We start your sub with the next scheduled issue, so please allow ten weeks for processing your subscription.

# Home Power MicroAds

**Rates: 10¢ per CHARACTER, include spaces & punctuation. $15 minimum per insertion. Please send check with ad. Your cancelled check is your receipt.**

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8' BAKER WINDMILL - NEVER USED! w/ windmill pump & pump cylinder. $1800 or best offer. Paul Yakovenko, Tenants Harbor, ME 04860 - 207-372-6322

******USED M51 MODULES $150--****** New PowerStar 1300 watt inverter $750, 700 watts $460, 400 watts, $370. Shipped Free. Used 100ah ni-cads $40 per cell. Used cable, inverters, generator**Craig POB 1802 Hesperia CA 92345, 619-949-9246 M/C, VISA, Discover (Will Beat Any Ads Price)

AMATEUR RADIO Communicate worldwide using your alternative energy source. Make friends and learn about electronics. New codeless license out now. Information, question & answer pools, and rules & regulations. Send $15 for everything you need to obtain an Amateur License to Dan Mobley Enterprises 1800 Williams St. Valdosta, GA 31602.

EXIDE STORAGE BATTERIES 2 Volt 250lb cells. 2020 amp hour, list $1,342 EACH. 3 years old, like new. 12 volt bank $950. 24 volt $1800. 34 volt $2500. Call Dave 417-683-3570

AMERICAN TROPICAL PARADISE! Contact Margaret A. Martin(RA) South Coast Realty, Inc. BIG ISLAND-HAWAII AFFORDABLE PROPERTIES. 808-929-9637(H) 808-929-7311(O)

WIND SPEED INSTRUMENTS $60 to $375, pedal power generator with sequential light load $285. Mountain Pass Wind, 711 N "C" St, Livingston, MT 59047 (406) 222-1707

ORGANIC BUILDING & DESIGN; All non-toxic materials. Experts in energy conservation & air quality. Plans, specs, & buildings available at reasonable cost nationwide. Remarc Inc. P.O.Box 174, Holderness, NH 03245 - 603-968-9678.

WANTED: Broken INVERTERS call Northern Power & Instrumentation at (206) 647-6953.

ANYONE CONTEMPLATING the purchase of used solar panels should consider this, BLACKHAWK SOLAR has new ARCO M-55 laminates in frames with warranty for $250. ea. Hurry limited quantities! Also incredible year-end specials on Trace, Kyocera, Wattsun, PowerStar, Cruising Meters, and Sun-Ovens. Remember don't buy anything solar WITHOUT calling BLACKHAWK SOLAR (916) 283-1396

JOSHUA TREE NATIONAL MONUMENT LEASE 1200 sq. ft. home - very secluded on 4800' mtn. Details: Tom Forman PO Box 1343, Joshua Tree, CA 92252

JACOBS WIND ELECTRIC replacement parts, new blades, and blade-actuated governors. We make replacement parts and have new blades for most all wind generators, pre-REA to present models. Many used parts, too. Lots of used equipment available: wind generators, towers, both synchronous and stand alone inverters, and Aermotor waterpumpers. Best prices on TRACE inverters and Bergey Wind Generators. Whisper 1000, $1260 and we pay shipping to anywhere in the lower 48. Trade Wind's wind odometer for $140.00, delivered. Information: $1; specify interests. Lake Michigan Wind & Sun, 3971 E Bluebird Rd., Forestville, WI 54213 Phone 414-837-2267.

THE COLUMBIA, 52", 4-bladed, brass 12 volt D.C. ceiling fan: Draws 0.4 amp, reversible motor and oak blades. For information on this and other models plus names of dealers, send S.A.S.E. to R.C.H., 2173 Rocky Creek Rd, Colville, WA 99114

1991 GUIDE TO UNUSUAL HOW-TO SOURCES. Describes 50 periodicals & handbooks on backyard tech, camping, crafts, finding new friends, gardening, home education, low-cost shelters, travel, woodslore, etc. All addresses are included. Free for SASE. Light Living Library POB 190-HP, Philomath, OR 97370

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MAKE FREE HYDROGEN FUEL from rain water and your renewable power source. Send for plans to make your own

gas generator or buy a ready made Water Electrolyzer. For plans and information, enclose $1.00 to - HYDROGEN WIND, INC., Lineville, Iowa 50147

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WANTED DISTRIBUTORS in Europe, Africa, Asia and South America for the most energy efficient D.C. powered ceiling fans available today. For free information packet, fax (509) 684-5286 or write R.C.H. 2173 Rocky Creek Rd. Colville, WA 99114 USA.

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CHINESE ONE CYLINDER DIESEL TRACTORS $3595. 3 wheels, comes with cultivator, up to 3 hrs. one gallon fuel. 7.5 KW Diesel Generator $2395. 12 HP Diesel Engine $995. China Farm Machinery Co., 23985 Rolling Meadows Dr., Perris, CA. 92570 Tel. 714-657-0379 Fax 714-657-8120. Protected dealerships available.

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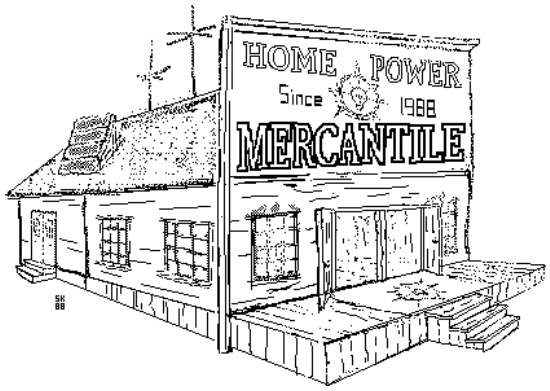
***Barkwheat, the solar-powered security system, thinks you should…***




One insertion per customer per issue. We typeset all ads and do the our best to make your ad look good. If you send too much copy, then you're bound to be disappointed. Flat Rate $80. Advance payment only, we don't bill Mercantile Ads. Your cancelled check is your receipt.

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ANYONE CONTEMPLATING the purchase of used solar panels should consider this, BLACKHAWK SOLAR has new ARCO M-55 laminates in frames with warranty for $250 ea. Hurry limited quantities!

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